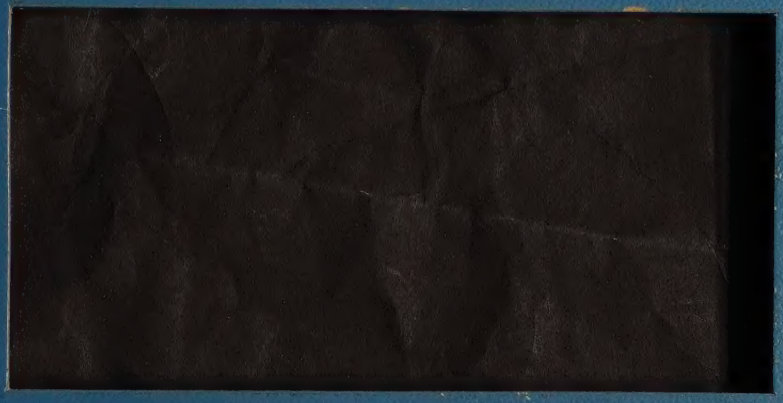

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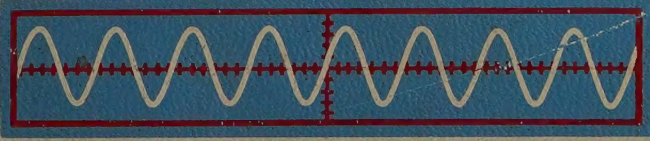

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Will Carter Return 6 32708

Instruction Manual
for
PHASE LOCK TRACKING FILTER
MODELS PL300 – PL307

Unit Serial No. _____

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PREFACE

This instruction manual presents descriptive, functional analysis, operation, and maintenance information for Phase Lock Tracking Filter Models PL300 - PL307. These units provide facilities to acquire and track noisy varying-frequency signals anywhere within a 100-cps to 120-kc frequency spectrum and produce constant-amplitude output signals phase-locked to the input.

This publication is intended for use primarily by technical personnel concerned with maintenance of these units. It is assumed that personnel maintaining these units have had training and experience with similar electronic equipment.

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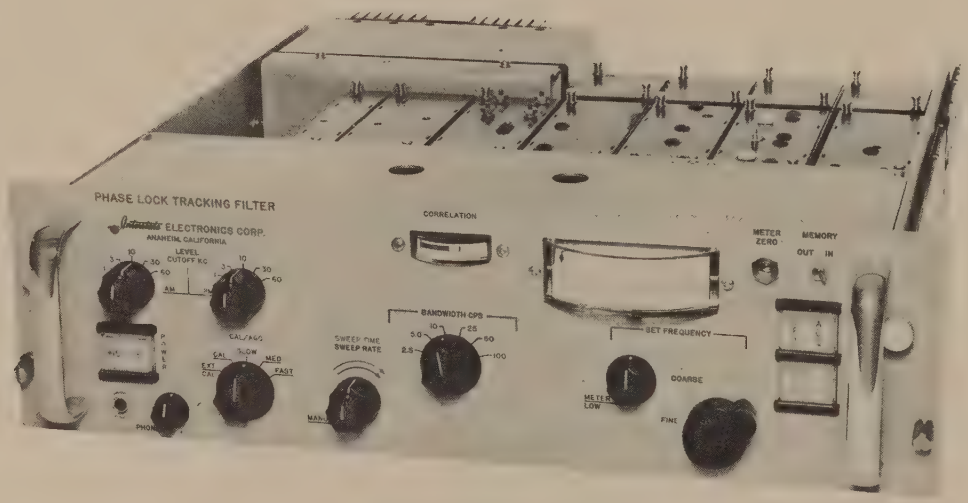

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Figure 1-1. Phase Lock Tracking Filter Model PL307

Chapter 1
GENERAL DESCRIPTION

1-1. INTRODUCTION.

a. PURPOSE. - Phase Lock Tracking Filter Models PL300 - PL307, illustrated pictorially in figure 1-1, is essentially a tunable bandpass filter employing a third-order phase-lock loop to track varying-frequency signals throughout a 0 to 120-kc noise bandwidth. The inherent sensitivity and accuracy of the phase-lock technique permit the filter to be applicable to both low and high-level data recovery problems such as oscillator stability studies, vibration analysis, and various cw Doppler and space positioning systems.

b. DESCRIPTION. - The tracking filter is equipped with slides for rack-mounted installations. The integral slide-tilt hardware facilitates access to all intra-module wiring and chassis-mounted components. Solid-state and modular construction is used throughout for maximum reliability and ease of maintenance. The tracking filter is completely self-contained and requires only input power and an input signal to function.

In system operation, the tracking filter acquires and tracks noisy varying-frequency signals anywhere within a 100-cps to 120-kc frequency spectrum. Bandwidth and agc time constants are selected by front-panel controls which may be adjusted during tracking to provide optimum filter response to weak and noisy input signals. Signal acquisition can be made manually or in either of two automatic modes. In a pilot mode, the filter is locked on to a pilot frequency until the true input signal crosses over the pilot frequency. The filter then discards the pilot frequency and locks on to the true input signal. While the filter is tracking a signal, it provides a constant-amplitude sinusoidal output signal phase-locked to the input signal. In accessory equipped models, the following additional outputs are provided: d-c analog of the phase-locked output frequency, and amplitude and phase-modulation data extracted from the input signal.

In addition to the outputs mentioned above, the following ancillary features are provided to make the tracking filter truely system application oriented and to aid the system designer: (1) form C relay contacts for drop-lock indication, (2) quadrature phase detector monitor for aids to signal acquisition, (3) aural indication of signal acquisition supplied to both the front panel and rear of the chassis, (4) provision for accepting an external precision reference frequency for maximum accuracy, (5) a level control and isolation circuits which are suitable for parallel operation of up

to ten units with negligible loading of a 600-ohm signal source, (6) a switchable back-up signal input, and (7) spare AN connector pins for coupling to circuit points of interest for analysis or monitoring.

The primary direct-current operating potentials required by the tracking filter are +15 and -15 volts. In some tracking filters these requirements are met by two identical power supply modules, while in other units a single supply module with dual outputs is employed. Descriptive and maintenance information, including schematic diagram and parts list, is provided in an appendix to this instruction manual. The wiring connections for each power supply option are shown in the power distribution diagram, figure 7-2.

The Models PL300 - PL307 series of tracking filters includes a basic model and seven accessory equipped variations of the basic model. The available accessories include auxiliary output facilities (frequency analog, correlated amplitude and phase-modulation demodulators), and a pilot acquisition feature. Table 1-1 provides accessory data on the Models PL300 - PL307.

1-2. REFERENCE DATA.

a. EQUIPMENT COMPLEMENT. - A list of equipment and accessories shipped with each tracking filter is contained in table 1-2. Plug-in printed circuit cards and modules used in the tracking filter are listed in table 1-3. Table 1-3 lists name, part number, and location of all modular subassemblies. The location column references the connector (X) designation as illustrated in figure 7-1.

b. SEMICONDUCTOR COMPLEMENT. - A complete listing of all transistors employed in the Model PL307 tracking filter is provided in table 1-4. All diodes employed in the Model PL307 are listed in table 1-5. These listings are by module assembly, so the semiconductors employed in the accessory assemblies (demodulator, pilot, and analog frequency amplifier) can be ignored as required for the other tracking filter models. All Interstate Technical Standard transistors are marked with the last six digits of the nine digit standards number or, where applicable, with the equivalent JEDEC designation. The Interstate Technical Standard semiconductor diodes are color coded. Brown, brown, orange, signifies Interstate Standard 343-111-003, and brown, red, brown, signifies Interstate Standard 343-212-001.

c. TECHNICAL SPECIFICATIONS. - Electrical and physical specifications for the tracking filter are listed in tables 1-6 and 1-7. Figure 1-2 is an outline drawing which gives pertinent mounting dimensions.

1-3. DIFFERENCE BETWEEN MODELS.

The text and illustrations in this manual refer to the Model PL307 which includes all accessories. However, the manual is organized so information not pertaining to a particular model can be ignored without affecting the continuity of the text. Information on modifications to a specific unit will be found on addendum pages in the front part of this manual.

TABLE 1-1. MODELS PL300 - PL307 ACCESSORY DATA

Model Number	Pilot Acquisition	Correlated Demodulators	Frequency Analog
PL300	-	-	-
PL301	-	X	-
PL302	X	-	-
PL303	-	-	X
PL304	-	X	X
PL305	X	X	-
PL306	X	-	X
PL307	X	X	X

TABLE 1-2. EQUIPMENT SUPPLIED

Quantity	Description	Part No.
1	Phase Lock Tracking Filter	9453000
4	Instruction Manuals	9453099
1	Power Cord	16200067
1	Test Adapter	9452500
1	Test Adapter	9452400
1	Lamp Tool	15PA19
17	Connectors	UG-88/U
1	Connector	AN3106A-18-1P
1	Slide, Left Hand	150843A-L
1	Slide, Right Hand	150843A-R
1	Clamp, Cable	AN3057-10

TABLE 1-3. EQUIPMENT COMPLEMENT

Name	Part Number	Location	PL 300	PL 301	PL 302	PL 303	PL 304	PL 305	PL 306	PL 307
Input Mixer/I-F Assembly	9460000	X5	1	1	1	1	1	1	1	1
Phase Detector/Reference Oscillator Assembly	9461000-502		1			1				
	9461000-503	X4		1	1		1		1	
	9461000-504							1		1
Equalizer Assembly	9462000	X6	1	1	1	1	1	1	1	1
VCO (X100) Output Assembly	9463000-501	X7	1	1	1	1	1	1	1	1
Loop Control Assembly	9464000	X8	1	1	1	1	1	1	1	1
Demodulator Assembly	9465000	X9		1			1	1		1
Divider Assembly	9466000	X11, X12	1	1	1	1	1	1	1	1
Pilot Assembly	9467000	X3			1			1	1	1
Reference Oscillator Assembly	9468000	X10	1	1	1	1	1	1	1	1
Analog Frequency Amplifier Assembly	9469000	X13				1	1		1	1
Bandswitch Card Assembly	9470000	X2	1	1	1	1	1	1	1	1
VCO Driver Card Assembly	9474000	X1	1	1	1	1	1	1	1	1

TABLE 1-4. TRANSISTOR COMPLEMENT

JEDEC Designation	Interstate Standard	Former Interstate Standard	Commercial	Reference Symbol	Quantity
Input Mixer/I-F Amplifier Assembly 9460000					
2N384	-	-	-	Q2	1
2N404	-	-	-	Q1	1
2N652	345-121-001	-	-	Q4	1
2N2270	-	-	-	Q3, Q5	2
Phase Detector/Reference Oscillator Assembly 9461000					
2N652	345-121-001	-	-	Q2, Q4, Q5	3
2N2270	-	-	-	Q1, Q3	2
Equalizer Amplifier Assembly 9463000					
2N652	345-121-001	-	-	Q8	1
2N859	345-221-001	-	-	Q3, Q4	2
2N2164	345-221-003	-	-	Q7, Q11	2
-	345-111-004	345-004	-	Q5	1
-	345-121-002	345-002	-	Q9, Q10, Q12, Q13	4
-	345-121-005	345-005	-	Q6	1
-	345-212-003	0173020	-	Q1, Q2	2
Loop Control Assembly 9464000 Correlation and AGC Amplifier Board 9464100					
-	345-111-001	345-001	-	Q4, Q11	2
-	345-111-004	345-004	-	Q7, Q14	2
-	345-121-002	345-002	-	Q2, Q3, Q5, Q9, Q10, Q13	6
-	345-121-005	345-005	-	Q6, Q13	2
-	345-212-003	0173020	-	Q1, Q8	2

Table 1-4. Transistor Complement (Continued)

JEDEC Designation	Interstate Standard	Former Interstate Standard	Commercial	Reference Symbol	Quantity
Loop Control Assembly 9464000 Sweep Amplifier and Drive Board 9464200					
-	345-111-001	345-001	-	Q4, Q7, Q9, Q10, Q12	5
2N652	345-121-001	-	-	Q11	1
-	345-121-002	345-002	-	Q2, Q3, Q5, Q6, Q8, Q13	6
-	345-212-003	0173020	-	Q1	1
Reference Oscillator Assembly 9468000					
2N1742	-	-	-	Q1, Q2, Q3	3
Calibration Oscillator Assembly 9451800					
2N2270	-	-	-	Q1	1
Analog Frequency Amplifier Assembly 9469000					
-	345-111-001	345-001	-	Q4	1
-	345-111-004	345-004	-	Q7	1
-	345-121-002	345-002	-	Q2, Q3, Q5	3
-	345-121-005	345-005	-	Q6	1
-	345-212-003	0173020	-	Q1	1
Pilot Assembly 9467000					
2N652	345-121-001	-	-	Q12	1
2N1225	-	-	-	Q1	1
-	345-111-001	345-001	-	Q5, Q10, Q11	3
-	345-111-004	345-004	-	Q8	1
-	345-121-002	345-002	-	Q3, Q4, Q6, Q9	4
-	345-121-005	345-005	-	Q7	1
-	345-212-003	0173020	-	Q2	1

Table 1-4. Transistor Complement (Continued)

JEDEC Designation	Interstate Standard	Former Interstate Standard	Commercial	Reference Symbol	Quantity
Demodulator Amplifier Assembly 9465000					
-	345-111-001	345-001	-	Q4, Q10	2
-	345-111-004	345-004	-	Q5, Q11	2
-	345-121-002	345-002	-	Q3, Q9	2
-	345-121-005	345-005	-	Q6, Q12	2
-	345-121-003	0173020	-	Q1, Q2, Q7, Q8	4
Divider Assembly 9466000					
2N652	345-121-001	-	-	Q3	1
2N708	-	-	-	Q1	1
2N1225	-	-	-	Q2	1
Divider Subassembly 9466700					
2N964	345-121-007	345-007	-	Q1, Q2 (Matched Pair)	2
Divider Subassembly 9466700-500					
2N964	345-121-007	345-007	-	Q1, Q2 (Matched Pair)	2
Divider Subassembly 9466700-501					
2N964	345-121-007	345-007	-	Q1, Q2 (Matched Pair)	2
Divider Subassembly 9466700-502					
2N964	345-121-007	345-007	-	Q1, Q2 (Matched Pair)	2
VCO Driver Assembly 9474000					
2N652	345-121-001	-	-	Q1, Q3, Q4	3
2N670	-	-	-	Q5	1
2N1485	-	-	-	Q2	1

Table 1-4. Transistor Complement (Continued)

JEDEC Designation	Interstate Standard	Former Interstate Standard	Commercial	Reference Symbol	Quantity
Voltage Controlled Oscillator Assembly 9463000-501 Component Board Assembly 9463400					
2N708	-	-	-	Q2, Q5, Q6, Q7	4
2N1225	-	-	-	Q4	1
2N1742	-	-	-	Q1	1
2N1743	-	-	-	Q3	1
Voltage Controlled Oscillator Assembly 9463000-501 Component Board Assembly 9463500					
2N598	-	-	-	Q6	1
2N652	345-121-001	-	-	Q7, Q8	2
2N708	-	-	-	Q3, Q4, Q5, Q9	4
2N1225	-	-	-	Q2	1
2N1743	-	-	-	Q1	1

TABLE 1-5. DIODE COMPLEMENT

JEDEC Designation	Interstate Standard	Former Interstate Standard	Commercial	Reference Symbol	Quantity
Input Mixer/I-F Amplifier Assembly 9460000					
1N99	-	-	-	CR3, CR4	2
1N270	-	-	-	CR5	1
-	-	-	C520	CR1, CR2	1 Pair
Phase Detector/Reference Oscillator Assembly 9461000					
-	-	-	C520	CR1 thru CR4	Note 1
Equalizer Amplifier Assembly 9463000					
1N99	-	-	-	CR6, CR7	2
1N629	-	-	-	CR2	1
-	343-212-001	343-001/343-005	-	CR1, CR3, CR4, CR5	4
Loop Control Assembly 9464000 Correlation and AGC Amplifier Board 9464100					
-	343-111-003	343-003	-	CR3, CR4, CR7, CR8	4
-	343-212-001	343-001/343-005	-	CR1, CR2, CR5, CR6	4
Loop Control Assembly 9464000 Sweep Amplifier and Drive 9464200					
-	343-111-003	343-003	-	CR3, CR4, CR7 thru CR12	8
-	343-212-001	343-001/343-005	-	CR1, CR2	2
-	-	-	1/4M 6.8Z5	CR5, CR6	2

Table 1-5. Diode Complement (Continued)

JEDEC Designation	Interstate Standard	Former Interstate Standard	Commercial	Reference Symbol	Quantity
Calibration Oscillator Assembly 9451800					
-	-	-	S555G	CR1	1
Analog Frequency Amplifier Assembly 9469000					
-	343-111-003	343-003	-	CR3, CR4	2
-	343-212-001	343-001/343-005	-	CR1, CR2	2
Pilot Assembly 9467000					
-	343-111-003	343-003	-	CR7 thru CR11	5
-	343-212-001	343-001/343-005	-	CR3 thru CR6	3
-	-	-	C520	CR1, CR2	1 Pair
Demodulator Assembly 9465000					
-	343-111-003	343-003	-	CR4, CR8	2
-	343-212-001	343-001/343-005	-	CR1 thru CR3, CR5 thru CR7	6
Divider Subassembly 9466700					
-	-	-	S555G	CR1 thru CR4	4
Divider Subassembly 9466700-500					
-	343-111-003	343-003	-	CR1 thru CR4	4
Divider Subassembly 9466700-501					
-	-	-	S555G	CR1 thru CR4	4
Divider Subassembly 9466700-502					
-	343-111-003	343-003	-	CR1 thru CR4	4

Note 1. Two through six matched pairs depending upon tracking filter model number.

TABLE 1-6. TECHNICAL SPECIFICATIONS, ALL MODELS

Parameter	Description
General	
System:	Third order phase-lock loop with correlated agc.
Phase-Lock Loop Tracking Bandwidth:	Adjustable to 2.5, 5, 10, 25, 50, or 100 cps.
Minimum S/N Ratio: (in 120-kc input noise bandwidth, based on 1/3-radian rms tracking error with with respect to same input and output frequencies)	Bandwidth / Min S/N Ratio / Min Signal RMS MV 2.5 cps / -38 db / 10 5 cps / -35 db / 14 10 cps / -32 db / 20 25 cps / -28 db / 31 50 cps / -25 db / 44 100 cps / -22 db / 62
Memory Circuit:	Last known frequency retained if signal drops out; if in automatic acquisition mode, automatic sweep resumes centered about last known frequency.
Signal Acquisition Modes:	Manual: Memory in/memory out toggle switch selection. Automatic: SWEEP TIME continuously adjustable from 0.2 to 10 seconds; SWEEP RATE continuously adjustable to a maximum of dial bandwidth squared cycles/sec/sec. Memory in/memory out toggle switch selection. Pilot: See table 1-5.
Internal Calibrate Oscillator:	20-kc crystal oscillator with usable harmonics to 120 kc.
Power Requirements	105-125 volts, 50 to 400 cps, 45 watts or less, depending upon accessory features; 210-250 volt operation obtained by proper selection of power supply taps.

Table 1-6. Technical Specifications, All Models (Continued)

Parameter	Description
Inputs (BNC Coaxial Connectors)	
Signal:	Frequency range 100 cps to 120 kc; internal low-pass input filter provided; cutoff frequency 150 kc. Amplitude approx 1.0-volt rms signal plus noise; input impedance approx 5,000 ohms. Internal level adjustment provided in order that multiple units may be driven from the same source.
External Calibrate:	A second signal input channel, selected from the front panel; all input characteristics same as above except no low-pass filter provided.
External Reference:	Provision for supplying precision reference frequency for detectors and output mixer; to be used only after performing filter modification outlined in chapter 4.
Pilot:	See table 1-5.
Outputs (BNC Coaxial Connectors)	
Phase-Locked Frequency:	x1 (100 cps - 120 kc); 1 volt rms min. impedance 500 ohms. x10 (1000 cps - 1.2 mc); 1 volt rms min. impedance 500 ohms. x100 (10 kc - 12 mc); 0.25 volt rms min. impedance 50 ohms.
Main Phase Detector Monitor:	0.5 volt min. impedance 0.5 megohm with 3000 pf to ground.
Auxiliary Phase Detector Monitor:	0.5 volt min; impedance 0.5 megohm with 3000 pf to ground.
Correlation Amplifier	-4 volts for 100% correlation; impedance 25,000 ohms.

Table 1-6. Technical Specifications, All Models (Continued)

Parameter	Description
AGC Voltage	-8 volts maximum; impedance less than 1 ohm; minimum load impedance 10,000 ohms.
Reference Oscillator:	250 kc, 0.1 volt rms; impedance 5000 ohms.
VCO Frequency:	1 volt rms minimum; impedance 500 ohms.
Phones (also front panel jack):	2 volts rms maximum; impedance 2000 ohms.
Correlation Relay Contacts:	Form C (spdt) a/n connector, mating connector supplied.
Operating Temperature	55^{o} C (130^{o} F) maximum.
Physical Specifications	
Dimensions:	19 in. wide by 5-1/4 in. high by 17-1/4 in. deep, excluding connectors and handles; heavy-duty slide tilt hardware included. (See figure 1-2.)
Weight:	40 lbs. maximum.

TABLE 1-7. ACCESSORY SPECIFICATIONS

Parameter	Description
Pilot Acquisition Control	
Input Frequency Range:	0 - 120 kc.
Input Level:	Approx. 0.5 volt rms; internal level adjustment provided.
Input Impedance:	Approx. 5000 ohms.
Front Panel Control/ Indicators:	Pushbutton selector switch with lock/drop lock lamps.

Table 1-7. Accessory Specifications (Continued)

Parameter	Description
Pilot Frequency Acquisition:	Manual or automatic; transfer to signal acquisition mode is automatic upon pilot acquisition. In event of signal drop lock in automatic mode, filter will search for signal when memory is in and search for pilot frequency when memory is out. Interlocked such that all pilot circuits are disabled while filter is tracking a true signal.
Correlated A-M and P-M Demodulators (Each Channel)	
Bandwidths:	Front panel adjustable: 1, 3, 10, 30 and 60 kc, -2%, +8%; roll off, 24 db/octave; low-frequency cutoff: 0.5 cps.
Output Levels:	Adjustable at front panel; one-volt peak-to-peak for 30% (a-m) or 30^{o} (p-m) modulation by a single-frequency signal.
Output Impedances:	Less than 1 ohm; requires minimum load of 2000 ohms.
Calibration:	Front panel controlled; internal 60-cps calibration signals provided for alignment and checkout of both demodulators.
Frequency Analog	
Output Level:	+10 volts to -10 volts for 0 to 120 kc (0 volts at 60 kc).
Output Impedance:	Less than 1 ohm, requires minimum load of 2000 ohms.
Linearity:	±5% of full scale.

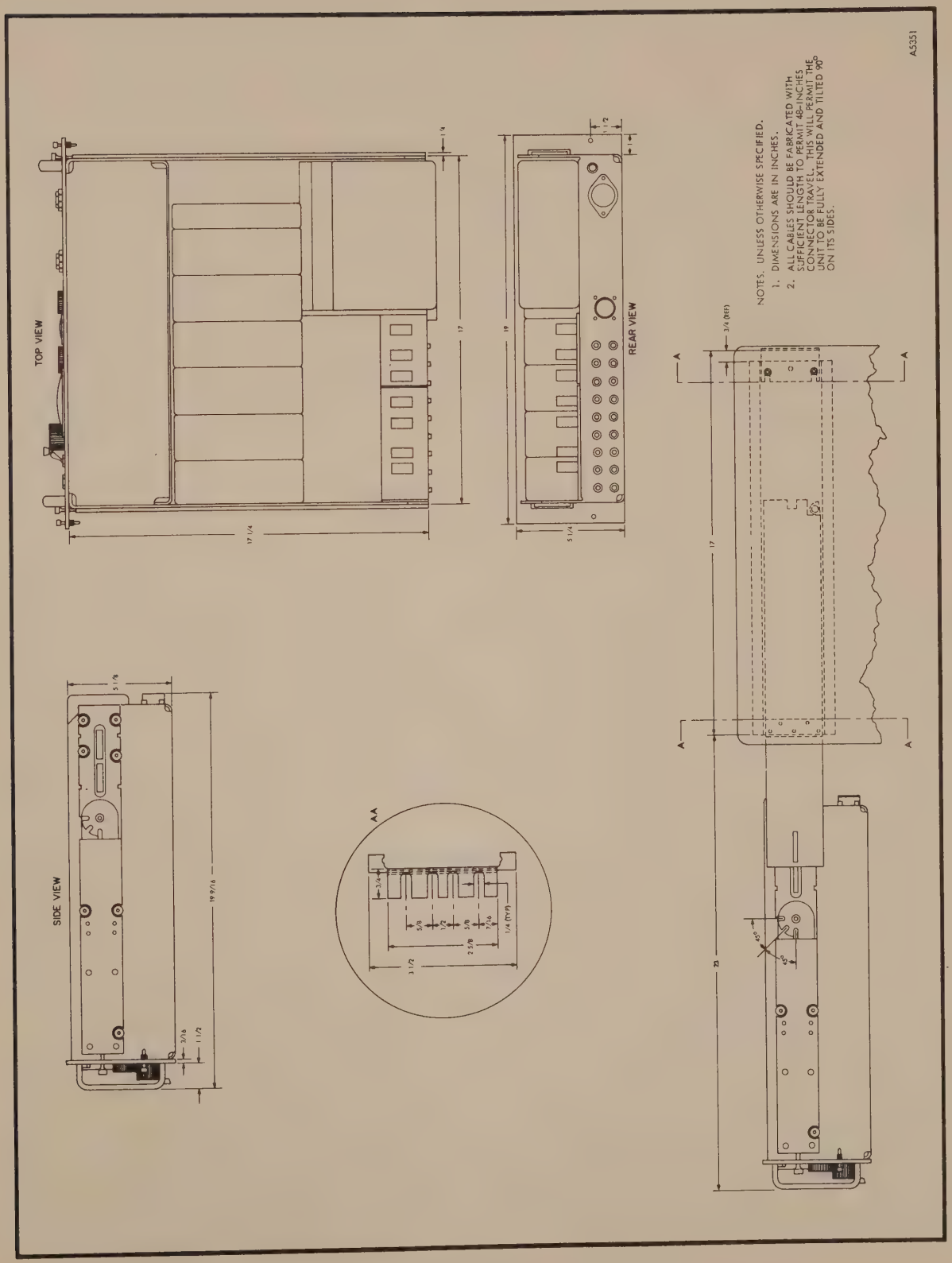
TOP VIEW
REAR VIEW
SIDE VIEW
AA
NOTES. UNLESS OTHERWISE SPECIFIED.
1. DIMENSIONS ARE IN INCHES.
2. ALL CABLES SHOULD BE FABRICATED WITH SUFFICIENT LENGTH TO PERMIT 48-INCHES CONNECTOR TRAVEL. THIS WILL PERMIT THE UNIT TO BE FULLY EXTENDED AND TILTED 90° ON ITS SIDES.
A5351

Figure 1-2. Phase Lock Tracking Filter Models PL300 - PL307, Overall Dimensions and Minimum Operating Clearance

NOTES

Chapter 2
FUNCTIONAL ANALYSIS

This chapter is divided into three sections. Section 1 provides a functional summary of the tracking filter on a basic block diagram level, followed by a detailed discussion of major components with reference to partial and simplified schematic diagrams. Section 2 gives a detailed operational sequence. Section 3 contains a detailed analysis of each plug-in assembly with reference to schematic diagrams. In all sections, reference is made to the overall system diagram in chapter 7 (figure 7-25).

Section 1. SYSTEM DESCRIPTION

2-1. FUNCTIONAL SUMMARY.

The tracking filter is essentially a tunable bandpass filter that employs a third-order phase-lock loop to track variable-frequency signals occurring anywhere in a 100-cps to 120-kc noise bandwidth.

The basic functional operation of the tracking filter is illustrated in figure 2-1. The following analysis describes the operation of the three major functional areas consisting of the basic phase-lock loop, loop control circuits, and loop accessories. Visual indication of the various modes of operation is provided by several multi-colored indicator lamps as described in table 5-2.

a. PHASE-LOCK LOOP. - The basic phase-lock loop is comprised of an input mixer, wide-band i-f amplifier, narrow-band i-f amplifier, main phase detector, equalizer network, vco driver and vco. The output of the vco is divided by 100 and fed back to the input mixer to complete the loop.

The applied signal is introduced to the input mixer where it is heterodyned with the divided vco output frequency to produce a 250-kc intermediate frequency. The i-f signal is then processed through 120-kc wide-band and 2.5-kc narrow-band amplifiers and applied to the main phase detector.

The main phase detector compares the phase relationship between the 250-kc i-f signal and a 250-kc reference signal. The output of the main phase detector is proportional to the cosine of the phase angle between the two signals so at 90 degrees, the averaged output of the phase detector is at null. Phase variations in the i-f signal drive the phase detector output negative or positive with respect to the null point, depending upon whether the signal advances or retards in phase relative to the reference frequency.

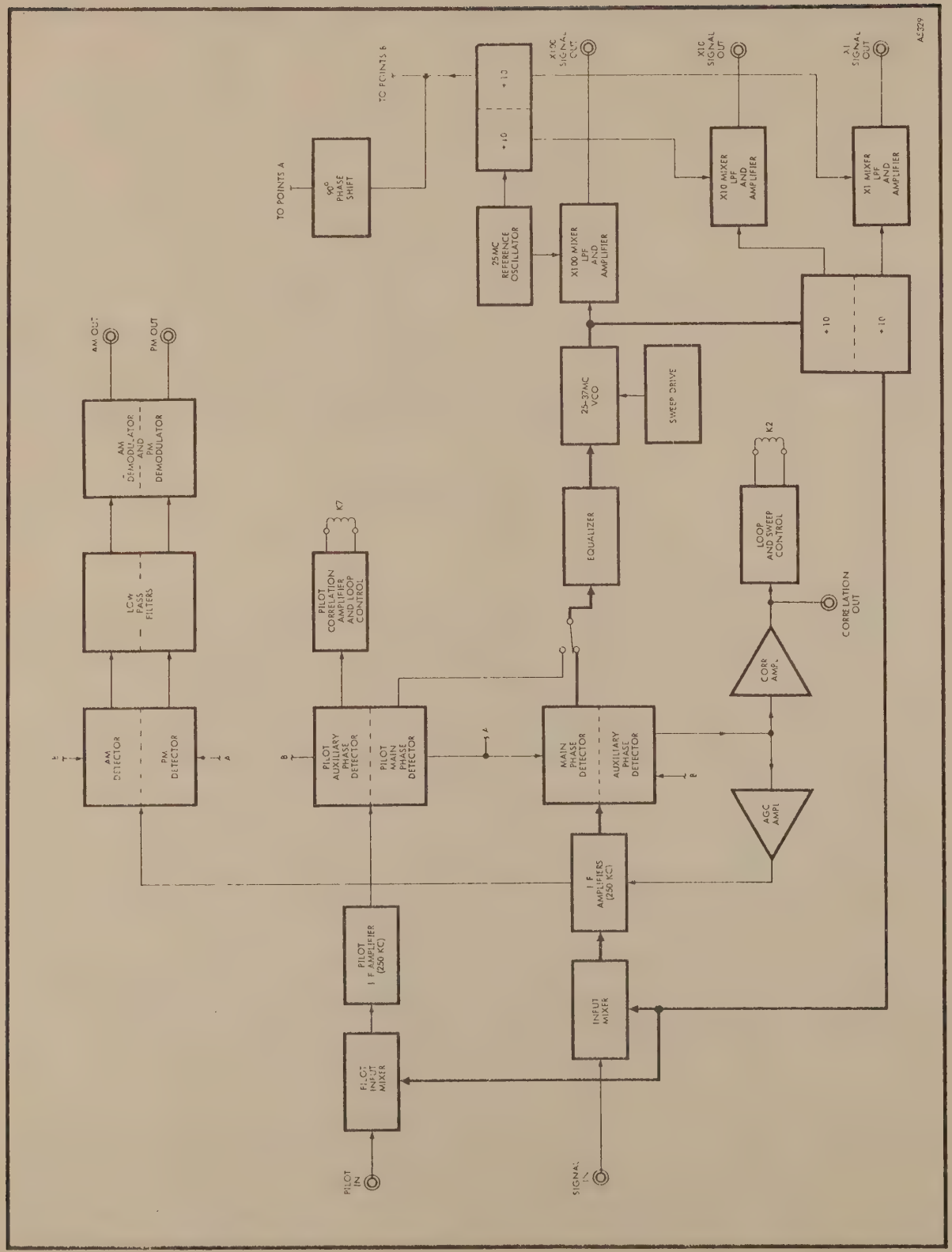

Figure 2-1. Phase Lock Tracking Filter Model PL 307, Basic Block Diagram

Error signals from the main phase detector are applied to an equalizer network consisting of a passive low-pass filter and an integrating amplifier. This network doubly integrates the error voltage from the main phase detector. The output of the equalizer is fed into a resistive summing network where it is added to the SET FREQUENCY control voltage to obtain the input voltage for the vco driver.

The vco driver stage provides control current for a controllable inductor which forms the frequency varying element in the vco. The vco responds to changes in its control current by changing its output frequency to a degree necessary to reduce the phase error to zero via the servo loop. The vco and its associated decade dividers provide the switching signal employed by the input mixer to generate the 250-kc i-f signal. The vco output frequency (25 mc to 37 mc) is also mixed with the 25-mc reference signal in an output mixer. The difference frequency is selected by a low-pass filter providing an output frequency 100 times the input frequency. The (x10) and (x1) outputs are created simultaneously with the (x100) output by mixing and filtering the divided vco and reference frequencies. Because the same reference and vco frequencies that give phase error information at the input are used to produce the output frequencies, inaccuracy and drift are cancelled out in terms of the input-output frequency relationship. The dividers are also phase stable; therefore, they introduce no errors in the divided reference or vco frequencies.

b. LOOP CONTROL CIRCUITS. - The loop control area is comprised of an auxiliary phase detector, agc amplifier, correlation amplifier, loop control threshold circuit, sweep drive and sweep amplifier circuit, and loop control relay logic circuits (figure 2-1). The auxiliary phase detector functions in the same manner as the main phase detector described in subparagraph a. Note, however, the 250-kc reference signal applied to the auxiliary phase detector is 90 degrees out of phase with the reference applied to the main phase detector. Because the i-f signal inputs to both phase detectors are in phase, it follows that the averaged output of the auxiliary phase detector will be maximum when the output of the main phase detector is zero. Thus, the output from the auxiliary phase detector provides an indication of the degree of correlation between the phase of the input signal and the phase of the reference signal. Loop closure is controlled by the loop control relay logic, and it can be effected in either manual, automatic, or pilot modes of operation.

In the MANUAL mode (SWEEP TIME control in the MANUAL detent), the vco is manually tuned in the open-loop condition (SET mode) until the beat frequency between the signal and the reference approaches zero. Phase-locked acquisition is then achieved by manually closing the loop (ACQ mode) and permitting the error signal to control the vco output in such a manner as to reduce the phase error to zero. In the automatic mode, the filter is manually tuned to the general region of the expected signal frequency. (The filter may be in either the SET or ACQ mode during the tuning because the SET FREQUENCY controls are independent of the acquisition mode.) When the ACQ mode is established, the sweep circuits will program the vco about the tuned frequency in accordance with the SWEEP TIME and SWEEP RATE control settings and the selected position of the BANDWIDTH CPS switch. When zero beat occurs, the auxiliary (quadrature) phase detector signal is amplified and triggers the threshold circuit of the loop control circuits. This initiates a relay logic sequence that permits phase lock to occur.

The auxiliary phase detector output is processed by the correlation amplifier for application to the CORRELATION meter and to the loop control threshold circuit. The CORRELATION meter may be monitored for a visual indication of zero beat between the reference and i-f signals while the filter is being tuned manually.

The agc amplifier is part of a secondary loop that employs the output of the auxiliary phase detector to control the gain of the i-f amplifier while the filter is tracking. After the signal has been acquired, the agc network controls the gain of the i-f amplifier to maintain a constant signal level at the auxiliary phase detector.

In the event of drop-lock, loop control relay logic is de-energized and the filter reverts to its pre-acquisition state with its tuned frequency determined by the setting of the front panel MEMORY switch.

The memory circuit incorporated into the equalizer network permits the last known frequency to be retained in the event of drop-lock. If the drop-lock was caused by signal fade, this feature eliminates the necessity for retuning the filter to reacquire the input signal when it reappears. The memory circuit establishes a d-c bias at the output of the equalizer proportional to the tracking frequency. When drop-lock occurs, the memory voltage retains the vco at the point of drop-lock, and acquisition occurs automatically should the input signal reappear at or near the same frequency. Because the loop is closed in the MANUAL mode, the memory circuit is not as stable as it is in automatic mode.

A detailed discussion of the various filter modes of operation and attendant switch and relay sequences is contained in section 2 of this chapter. The unique operational aspects of the pilot acquisition control accessory are further discussed in section 2 and subparagraph c below.

c. LOOP ACCESSORIES. - One acquisition aid (pilot acquisition control), and two data processing aids (a-m and p-m demodulator outputs and frequency analog output) are available as optional accessories.

The pilot acquisition control feature provides programming or precision tuning of the filter in a phase-locked mode to any local (pilot) frequency source in order to facilitate automatic acquisition of a desired incoming signal. The pilot signal is acquired in a conventional manner, and once acquired, the filter will remain phase-locked to the pilot until such time as the presence of a true signal triggers the loop control threshold circuits. At that time, the filter will automatically acquire the true signal and ignore the pilot signal. When the memory circuit is in, the pilot frequency cannot be reacquired until the filter is manually returned to the SET mode.

The correlated demodulator outputs provide amplitude and phase-modulation data extracted from the input frequency. The synchronously demodulated sideband signals are processed through selectable bandwidth low-pass filters and amplified by wide-dynamic-range video amplifiers. Individual output level controls and calibration signals for preoperational testing are provided for both demodulator channels.

The frequency analog output provides a d-c voltage analog of the frequency being tracked. In order to provide maximum resolution over the 120-kc tracking range, zero cps is made to correspond to +10 volts while -10 volts corresponds to 120 kc. The linearity of this voltage is dependent upon the control current characteristics and hysteresis of the controllable inductor in the vco.

2-2. PHASE-LOCK LOOP.

The following subparagraphs describe the phase-lock loop with reference to the overall system diagram in chapter 7 (figure 7-25).

a. INPUT CIRCUITS. - The input frequencies are introduced at the SIG IN coaxial connector and passed via a low-pass filter to CAL/AGC switch S11. The CAL/AGC switch permits selection of signal or calibration inputs to the input mixer. Calibration signals may be acquired and tracked from an internal crystal-controlled 20-kc oscillator or from an external source connected to the EXT CAL coaxial connector at the chassis rear. The agc positions of switch S11 permit selection of slow, medium, or fast agc response. The EXT CAL coaxial connector provides a second input signal channel as well as a calibration input. Either of the input channels may be selected with the CAL/AGC switch, and they differ only in that the normal input channel is provided with a low-pass filter and selectable agc time constants. The EXT CAL position of the CAL/AGC switch uses the fast agc time constant. In the following paragraphs, it is assumed that the tracking filter has acquired a 20-kc calibrating signal.

b. INPUT MIXER. - A simplified schematic diagram of the input mixer, showing input and output waveforms, is given in figure 2-2. The purpose of the input mixer is to heterodyne the input frequency (20 kc in this example) with the vco output frequency (270 kc) to produce a 250-kc i-f signal. Because the signal source may be driving several equipments with various level requirements, the INPUT LEVEL ADJ control is provided to ensure that the rms signal plus noise level never exceeds 1 volt rms. The vco output (270 kc in this example) produces the switching signal for the input mixer, which is balanced, so the fundamental frequency component of the switching signal is minimized at the output. At input frequencies below approximately 1500 cps, optimum performance of the filter depends upon critical mixer balance. The output resulting from the switching action is shown in figure 2-2 (waveform D). Integral components of the mixer output are the input frequency (20 kc), switching signal minus input frequency (250 kc), and switching signal plus input frequency (290 kc). Note that the fundamental 270-kc switching signal itself is not available at the output.

c. I-F AMPLIFIERS. - The output of the mixer is fed to a 250-kc i-f amplifier. The first stages of this amplifier operate at a bandwidth of 120 kc to drive the correlated demodulators (optional accessory). The final stage reduces the overall bandwidth to approximately 2.5 kc and furnishes the signal inputs to the main and auxiliary phase detectors. Idealized response curves for the i-f amplifier are shown in figure 2-3.

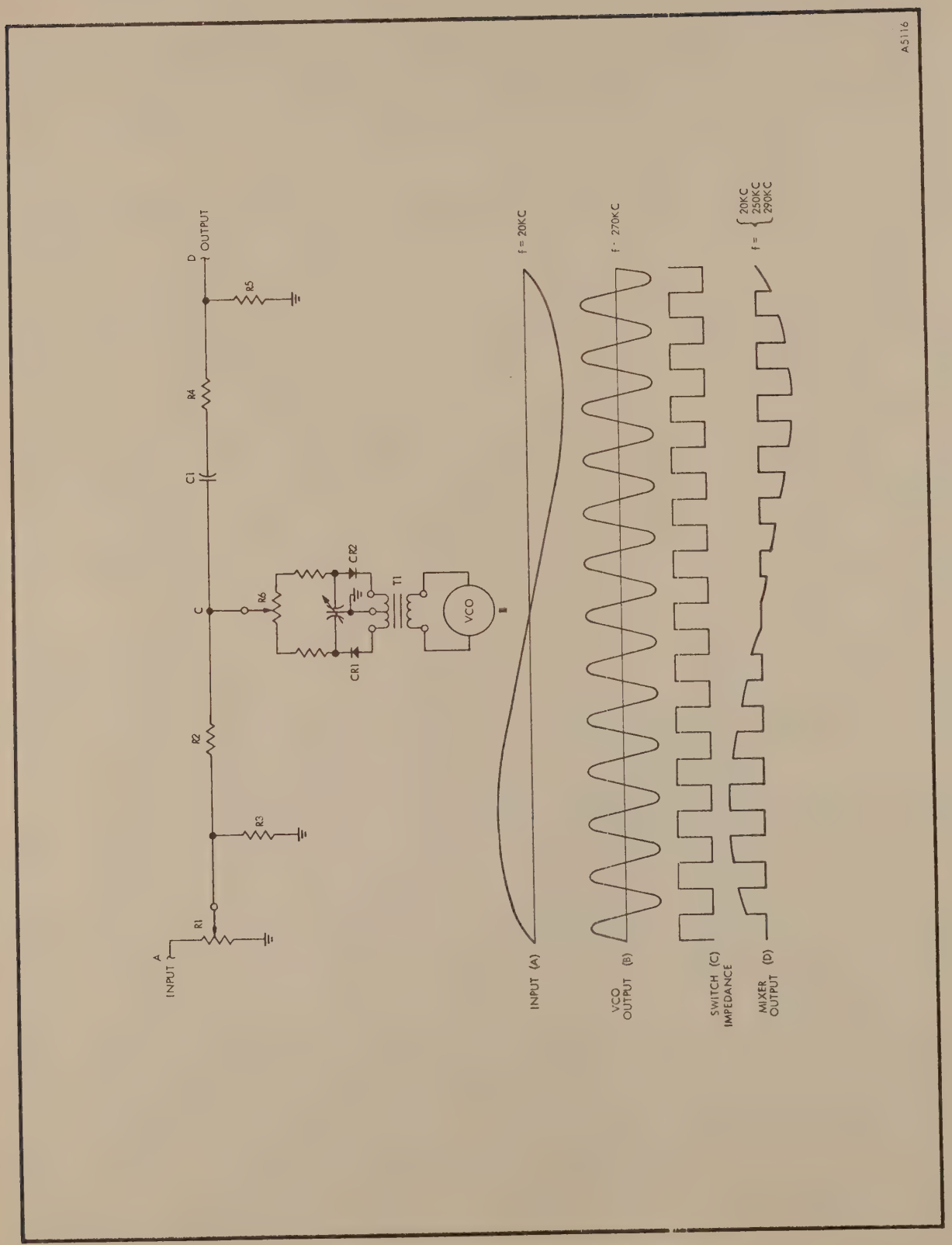

Figure 2-2. Input Mixer, Simplified Schematic Diagram

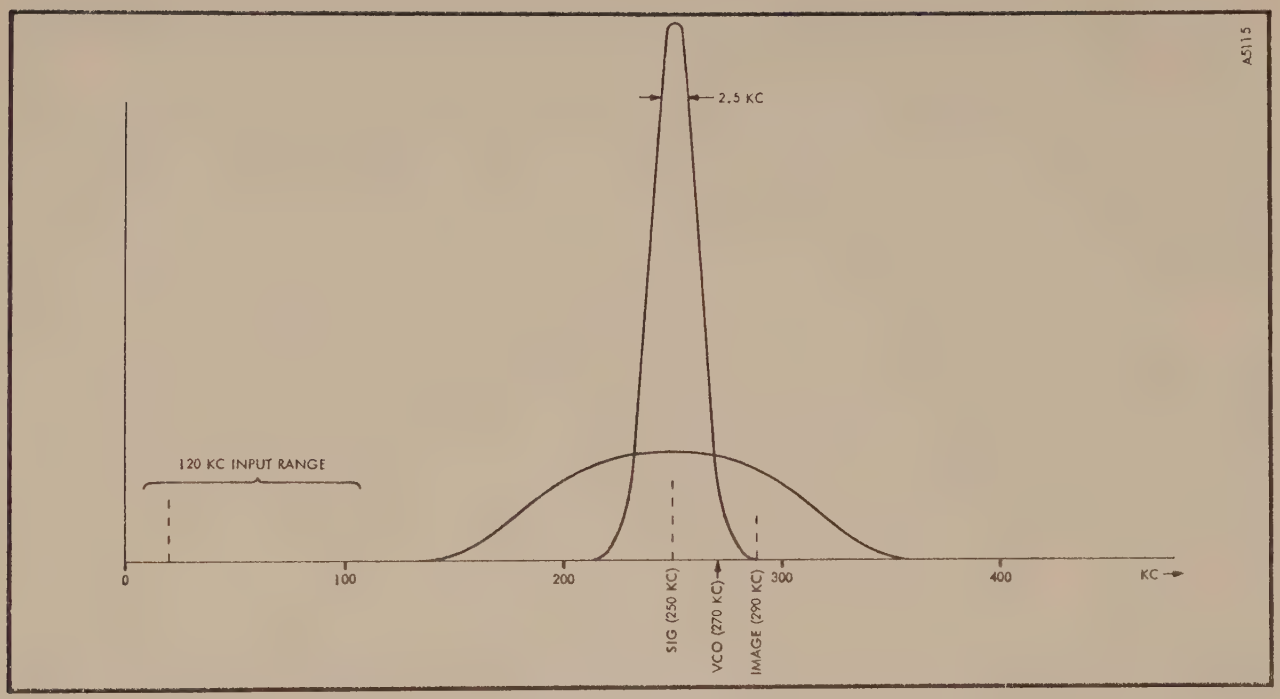

Figure 2-3. Idealized I-F Amplifier Frequency Response

d. MAIN PHASE DETECTOR. - The main phase detector is almost identical to the input mixer shown in figure 2-2. The two circuits are functionally similar also, except that the phase detector acts as a half-wave phase comparator between the 250-kc i-f signal and the 250-kc reference signal, rather than as a balanced mixer. Figure 2-4 illustrates idealized waveforms for phase-locked tracking condition, in which the phase difference between the two input signals is 90 degrees with the reference signal leading. Note that the switching action of the reference signal effectively grounds the phase detector output for exactly half of the 250-kc period. As demonstrated by equal positive and negative excursions during the half cycle the output is not grounded, the average d-c level (phase error) at the output of the phase detector is zero when the loop is phase-locked.

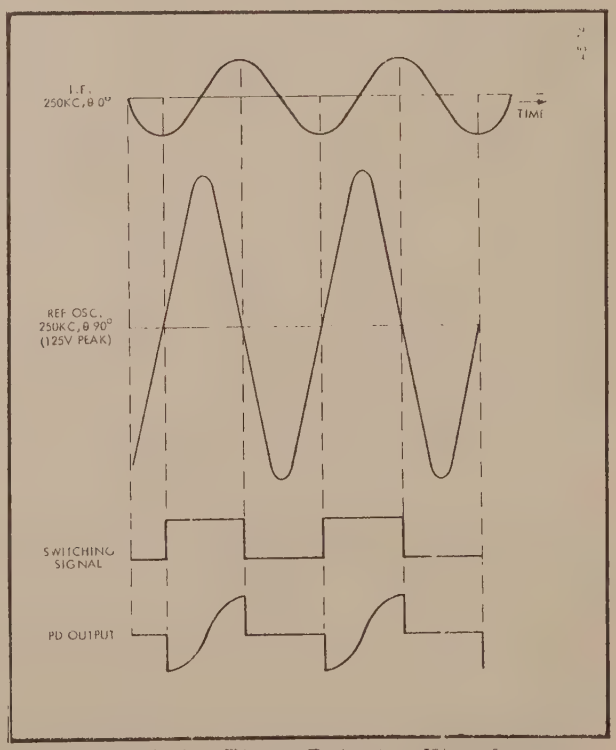

Figure 2-4. Phase Detector Waveforms, Simplified Diagram

Figure 2-5 illustrates changes in average phase error incurred by 10-degree phase shifts in the i-f signal with respect to the stable reference signal. As the phase of the i-f signal advances or retards with respect to the reference signal, the average phase error incurred is positive or negative, respectively.

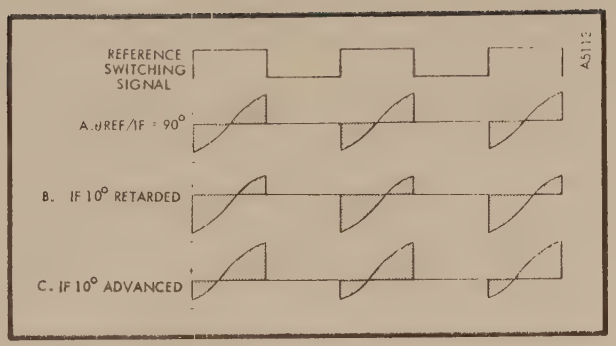

Figure 2-5. Phase Detector Output, Null, 10^{O} Phase Retarded, and 10^{O} Phase Advanced

e. EQUALIZER NETWORK. - The phase error output of the main phase detector is introduced to the equalizer network through relay contacts K3A, and BANDWIDTH CPS switch S9. The BANDWIDTH CPS switch establishes the tracking bandwidth at 2.5, 5, 10, 25, 50, or 100 cps by selection of suitable resistor networks to control the response of the equalizer. Most network components are located on the bandswitch card illustrated in figure 7-5.

The overall equalizer network is illustrated in figure 2-6. In the ACQ mode, the phase error from the main phase detector is fed via the BANDWIDTH CPS switch to the first integrator. This integrator filters high-frequency noise and integrates the phase error for application to the equalizer amplifier (second integrator). The equalizer amplifier is a chopper-stablized d-c amplifier which functions as a high-gain operational amplifier when capacitor C_m is shunted, or as a near perfect integrator when tracking or when the memory circuit is in (C_m not shunted).

f. VCO DRIVER. - The output voltage of the equalizer amplifier is fed into a resistive summing network where it is algebraically summed with the SET FREQUENCY control voltage to obtain the input voltage for the vco driver. (See figure 2-6.) In automatic search mode, the sweep signal is also applied to the summing network. The vco driver provides control current for the controllable inductor to vary the frequency of the vco over the range from 25 mc to 37 mc. The vco responds to voltage changes at the summing junction by changing its frequency to a degree necessary to cancel the phase error in the phase-lock loop. The vco output is then fed through a divide-by-100 circuit before returning to the input mixer to close the loop.

2-3. LOOP ACCESSORIES.

The following subparagraphs describe the loop accessories which include the pilot acquisition control, a-m and p-m correlated demodulator outputs, and the frequency analog output.

a. PILOT ACQUISITION CONTROL. - The circuits of the pilot acquisition control are similar to the phase-lock loop discussed in paragraph 2-2 in that they consist of an independent input mixer, i-f amplifier, main and auxiliary phase detectors, correlation amplifier, and loop control circuit. The pilot acquisition control permits the tracking filter to phase-lock to an externally supplied pilot frequency. When the true frequency crosses over the pilot frequency, the tracking filter automatically acquires the true frequency and discards the pilot; thus, the tracking filter can be tuned to a given frequency and will remain there, drift free, until a signal of the same frequency appears at the input.

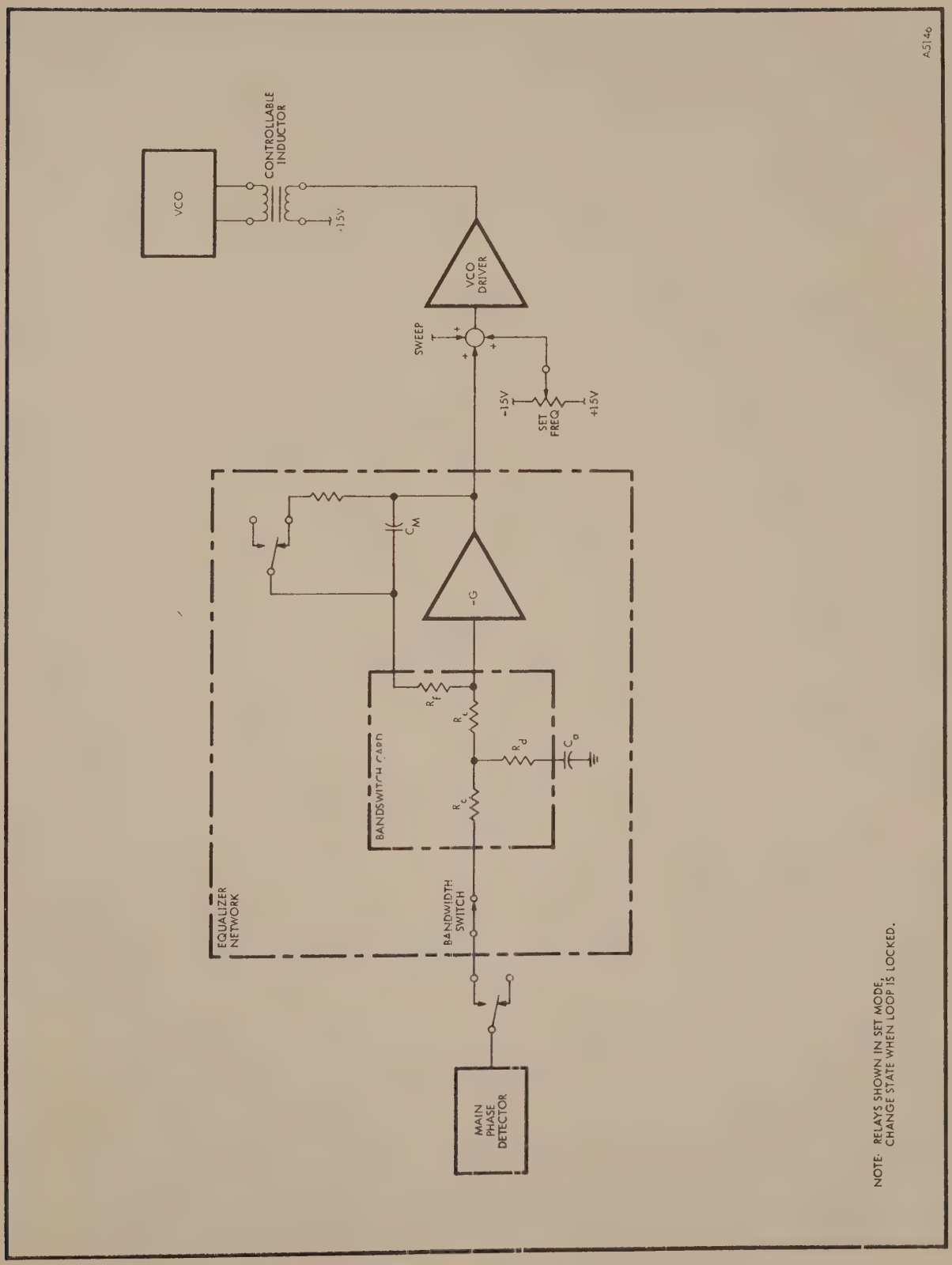

Figure 2-6. Equalizer Network, Simplified Schematic Diagram

The presence of the pilot signal in no way interferes with the normal performance of the tracking filter, and the transfer from pilot to true signal is completely automatic. This switchover is accomplished in exactly the same manner as for the case of automatic signal acquisition without pilot as discussed in paragraph 2-1b. Because a clear, high-level, locally generated signal is required for the pilot frequency, no agc control is used in the pilot i-f circuit. An internal PLT LEVEL (pilot level) control is provided in order that proper drive level may be obtained. Proper drive level is indicated by 100 percent on the CORRELATION meter after the pilot signal has been acquired.

b. CORRELATED A-M AND P-M DEMODULATOR OUTPUTS. - The correlated a-m and p-m demodulators use the wide-band i-f amplifier to drive quadrature phase detectors which synchronously demodulate amplitude and phase-modulation data from the input frequency being tracked. The phase detectors serve as coherent detectors to the extent that the input signal-to-noise ratio permits 100 percent correlation between the signal and the reference oscillator. The a-m and p-m demodulated signals are processed through variable bandwidth low-pass filter networks and video amplifiers, and are made available at coaxial connectors at the rear of the chassis. The attenuation of the filter networks is 24 db per octave. Five front panel selectable corner frequencies, ranging from 1 kc to 60 kc, are provided. The video amplifiers are a-c coupled to the phase detectors to provide a low-frequency response of 0.5 cps.

c. ANALOG FREQUENCY OUTPUT. - The vco driver circuit supplies a voltage which is amplified to provide a d-c voltage analog of the frequency being tracked; +10 volts equals zero cps, 0 volts equals 60 kc, and -10 volts equals 120 kc. This voltage is amplified and applied to the ANAL connector on the rear of the chassis where it is available for connection to an external recorder or remote monitor.

Section 2. DETAILED OPERATIONAL SEQUENCE

The following paragraphs describe the sequence of operations selectable by front-panel controls and performed by loop control relays for each operational mode. Figure 7-24 is a loop control relay logic diagram which can be refered to for clarification of the following description.

2-4. AUTOMATIC ACQUISITION, MEMORY IN.

To establish this mode, the SWEEP TIME control is rotated out of the MANUAL detent, the MEMORY switch is IN, and the SET/ACQ switch is at SET.

a. SET. - During the initial SET condition all relays are de-energized. Relay contacts K3A hold the equalizer input open, and contacts K3B ground the output of the main phase detector. The output of the pilot main phase detector is grounded by relay contacts K7A. These conditions permit the filter to be tuned by means of the COARSE and FINE SET FREQUENCY controls to establish the sweep center frequency.

b. ACQUIRE. - The SET/ACQ switch is pressed to establish an ACQ condition. This energizes relay K1 (S6A) and causes the ACQ lamp to glow green (S6B and memory in). Relay contacts K1A then energize relay K4 which starts the automatic sweep (K4A and K4B) and disables the memory circuit (K4D). In addition, the pilot and main loop control circuits are prepared for acquisition by relay contacts K1C and K1D, respectively. The filter is now ready to acquire in either the normal automatic or pilot mode of operation, depending upon the setting of the PLT/SIG switch.

c. SIGNAL ACQUIRED. - With the PLT/SIG switch in the SIG position, the pilot input is grounded through switch S7B and relay contacts K7D. The internal sweep programs the vco until the output of the main loop correlation amplifier triggers main loop control relay K2. Relay contacts K2A then de-energize relay K4 which stops the sweep (K4A and K4B) and enables the memory circuits (K4D). Contacts K2A also energize relay K3 which connects the main phase detector to the equalizer (K3A). Relay contacts K2B energize relay K5 which provides a "hold" inhibit on the pilot circuits by grounding the pilot input (K5B), and disables relay K6. Relay contacts K2C provide a return to ground for the SIG lamp which glows green to indicate lock on.

d. DROP-LOCK. - Loss of input signal is reflected by loss of output from the main loop correlation amplifier, which de-energizes relay K2. Relay K5, however, remains energized via holding contacts K5C, switch S1, and relay contacts K1A. With relay K2 de-energized, relay K3 is opened and relay K4 is closed (K2A). This reverts the loop to its pre-acquisition state, except that the sweep is now centered approximately* around the drop-lock frequency (memory still enabled by K5D); the main phase detector is disconnected from the equalizer (K3A), the internal sweep is started (K4A and K4B), and the SIG lamp glows yellow (K2C), indicating drop-lock.

2-5. MANUAL ACQUISITION, MEMORY IN.

To establish this mode the SWEEP TIME control is placed in the MANUAL detent, the MEMORY switch is IN, and the SET/ACQ switch indicates SET.

a. SET. - During the initial SET condition, all relays are de-energized. Relay contacts K3A hold the equalizer input open and contacts K3B ground the output of the main phase detector. The output of the pilot main phase detector is grounded by relay contacts K7A. These conditions permit the filter to be tuned by means of the COARSE and FINE SET FREQUENCY controls to establish an input frequency in the vicinity of the input signal.

b. ACQUIRE. - The SET/ACQ switch is pressed to establish an ACQ condition. This action energizes relay K1 and causes the ACQ lamp to glow green (memory in). Relay contacts K1A then energize relay K3 (via MANUAL position of switch S10), which connects the main phase detector to the equalizer (K3A) and grounds the pilot main phase detector (K3B). Relay contacts K1B enable the memory circuit (C_m) and contacts K1C and K1D close the pilot and main loop control circuits. The

*"Approximately" refers to the short-term velocity-controlled prediction of the memory circuit. If the filter had been tracking a static frequency, it would have remained at the frequency at which drop-lock occurred.

loop is now ready to acquire, provided that the phase error observed at the main phase detector is within the pull-in range of the loop. The vco may be tuned, using the SET FREQUENCY controls, toward zero beat as indicated by the CORRELATION meter or the head phones to establish acquisition.

c. SIGNAL ACQUIRED. - The output from the correlation amplifier triggers the main loop control circuit, closing relay K2. Relay contacts K2A sustain the relay K3 closure (main loop complete). Contacts K2B energize relay K5. Relay contacts K5A, K5B, and holding contacts K5C provide a "hold" inhibit on the pilot circuits by grounding the pilot input (K5B) and opening the relay K6 circuit (K5A). Relay contacts K2C provide a return to ground for the SIG lamp which glows green, indicating lock on.

d. DROP-LOCK. - Loss of input signal is reflected by loss of output from the main loop correlation amplifier, which de-energizes relay K2. Relay K3 is held on to provide a complete loop (K3A) by virture of contacts K2A. Relay K5 continues a pilot inhibit by means of holding contact K5C and MEMORY switch S1A. The SIG lamp glows yellow (K2C) indicating drop lock. The filter will now remain at approximately the last known frequency, although drift will be excessive in the MANUAL mode unless the main phase detector is very carefully balanced. Because the loop is closed through relay contacts K3A, phase detector offset will be integrated by the equalizer network to establish a drift rate in the vco. If necessary the vco may be tuned using the SET FREQUENCY controls to establish signal acquisition. Equalizer offset may cause the range of the SET FREQUENCY controls to be indequate to acquire the input signal. If this problem exists, return to the SET mode and acquire by repeating steps a and b.

2-6. AUTOMATIC ACQUISITION, MEMORY OUT.

To establish this mode, the SWEEP TIME control is rotated out of the MANUAL detent, the MEMORY switch is OUT, and the SET/ACQ switch is at SET.

a. SET. - During the initial SET condition, all relays are de-energized. Relay contacts K3A hold the equalizer input open and contacts K3B ground the output of the main phase detector. The output of the pilot main phase detector is grounded by relay contacts K7A. These conditions permit the filter to be tuned by means of the COARSE and FINE SET FREQUENCY controls to establish the sweep center frequency.

b. ACQUIRE. - The SET/ACQ switch is pressed to establish an ACQ condition. This energizes relay K1 and causes the ACQ lamp to glow yellow (memory out). Relay contacts K1A then energize relay K4 which starts the automatic sweep (K4A and K4B) and disables the memory circuit (K4D). In addition, the pilot and main loop control circuits are closed by relay contacts K1C and K1D, respectively. The filter is now ready to acquire in either the normal automatic or pilot mode of operation, depending upon the setting of the PLT/SIG switch.

c. SIGNAL ACQUIRED. - With the PLT/SIG switch in the SIG position, the pilot input is grounded through switch S7B and relay contacts K7D. The internal sweep programs the vco until the output of the main loop correlation amplifier triggers main loop control relay K2. Relay contacts K2A then de-energize relay K4, which stops the sweep (K4A and K4B) and enables the memory circuits (K4D). Contacts K2A also energize relay K3 which connects the main phase detector to the equalizer (K3A). Relay contacts K2B energize relay K5 which provides a "hold" inhibit on the pilot circuits by grounding the pilot input (K5B) and disabling the relay K6 circuit. Relay contacts K2C provide a return to ground for the SIG lamp which glows green to indicate lock-on.

d. DROP-LOCK. - Loss of input signal de-energizes relay K2 as described earlier. Contacts K2A then de-energize relay K3 and energize relay K4. This action disconnects and grounds the main phase detector (K3A and K3B), starts the sweep (K4A and K4B), prepares the memory circuit for inhibit (K4D), switches the SIG lamp to yellow, indicating drop-lock (K2C), and de-energizes relay K5 (K2B). In the de-energized state, relay K5 inhibits the memory circuit (K5D) and prepares the loop control network for possible reacquisition of the pilot signal, the pilot input is ungrounded (K5B), and the relay K6 circuit is prepared for energizing by relay contacts K5A in the event that the PLT/SIG switch is in PLT. *The vco returns to sweep about the frequency determined by the position of the SET FREQUENCY controls.* If adjustment of the sweep center frequency is required, it may be more easily accomplished by returning to the SET mode, especially in cases involving wide, slow sweep.

2-7. MANUAL ACQUISITION, MEMORY OUT.

To establish this mode, the SWEEP TIME control is placed in the MANUAL detent, the MEMORY switch is OUT, and the SET/ACQ switch is at SET.

a. SET. - During the initial SET condition, all relays are de-energized. Relay contacts K3A hold the equalizer input open and contacts K3B ground the output of the main phase detector. The output of the pilot main phase detector is grounded by relay contacts K7A. These conditions permit the filter to be tuned by means of the COARSE and FINE SET FREQUENCY controls to establish an operating frequency in the vicinity of the input signal.

b. ACQUIRE. - The SET/ACQ switch is pressed to establish an ACQ mode condition. This action energizes relay K1 and causes the ACQ lamp to glow yellow (memory out). Relay contacts K1A then energize relay K3 (via MANUAL position of switch S10) which connects the main phase detector to the equalizer (K3A) and grounds the pilot main phase detector (K3B). Relay contacts K1B enable the memory circuit (C_m) and contacts K1C and K1D close the pilot and main loop control circuits. The loop is now ready to acquire, provided that the phase error observed at the main phase detector is within the pull-in range of the loop. The vco may be tuned, using the SET FREQUENCY controls, toward zero beat as indicated by the CORRELATION meter or the head phones, to establish acquisition.

c. SIGNAL ACQUIRED. - The output from the correlation amplifier triggers the main loop control circuit, closing relay K2. Relay contacts K2A sustain the relay K3 closure (main loop complete). Contacts K2B energize relay K5 which provides a "hold" inhibit on the pilot circuits by grounding the pilot input (K5B) and opening the relay K6 circuit (K5A). Relay contacts K2C provide a return to ground for the SIG lamp which glows green, indicating lock on.

d. DROP-LOCK. - Loss of input signal de-energizes relay K2. Contacts K2A hold relay K3 on via the MANUAL position of switch S10. Relay contacts K2C cause the SIG lamp to glow yellow, indicating drop lock; and contacts K2B de-energize relay K5. In the de-energized position, relay K5 again prepares the loop control network for possible acquisition in the pilot mode. Should the PLT/SIG switch be set to PLT, the pilot input is ungrounded (K5B) and the relay K6 circuit is prepared by contacts K5A for action in the pilot mode. Note that the memory circuit is always active in the manual acquisition modes (SWEEP TIME switch S10 holds relay K4 open, thus preventing contacts K4D from shunting the memory capacitor). This does not create a problem in reacquiring the signal because the SET FREQUENCY controls still permit the filter to be tuned. A problem of adequate SET FREQUENCY control range may be encountered, however, because the output of the equalizer is offset from zero and the SET FREQUENCY controls must counteract the offset. Should this not be possible, it will be necessary to return to the SET mode and reacquire in the normal manner.

2-8. PILOT ACQUISITION IN AUTOMATIC MODE, MEMORY IN.

To establish this mode, the SWEEP TIME control is rotated out of the MANUAL detent, the MEMORY switch is IN, the SET/ACQ switch is at SET, the SIG lamp glows yellow, and the PLT lamp is extinguished.

a. SET. - During the initial SET condition, all relays are de-energized. Relay contacts K3A hold the equalizer input open and contacts K3B ground the output of the main phase detector. The output of the pilot main phase detector is grounded by relay contacts K7A. These conditions permit the filter to be tuned to establish a sweep center frequency in the vicinity of the pilot input.

b. ACQUIRE PILOT. - For pilot acquisition, the PLT/SIG switch is pressed to establish a PILOT mode. This energizes relay K6 and results in the following action: the PLT lamp glows yellow and the SIG lamp is extinghished (K6D), the CORRELATION meter indicates the output of the pilot loop correlation amplifier (K6A), and relays K3 and K5 are prevented from energizing (K6C). With relays K3 and K5 de-energized, the tracking loop is open (K3A and K3B) and the pilot input is ungrounded (K5B and S7B). The SET/ACQ switch is then pressed to establish an ACQ mode. This energizes relay K1 and causes the ACQ lamp to glow green (memory in). Relay contacts K1A then energize relay K4 which starts the internal sweep (K4A and K4B) and disables the memory circuit (K4D). In addition, the pilot and main loop control circuits are prepared for acquisition by relay contacts K1C and K1D, respectively. The loop is now ready to acquire the pilot signal and the vco is being swept about the SET FREQUENCY control setting.

c. PILOT ACQUIRED. - The output of the pilot correlation amplifier triggers relay K7. With relay K7 energized, the pilot main phase detector is connected to the equalizer (K7A), relay K4 is de-energized disabling the sweep (K7B), the CORRELATION meter is held at the output of the pilot correlation amplifier by relay contacts K7C, relay K6 is de-energized, and a ground return is provided for the PLT lamp (green) by contacts K7D. Relay contacts K6C prepare relays K3 and K5 for normal operation (acquisition of signal input). Relay contacts K6D extinguish the yellow PLT lamp and illuminate the yellow SIG lamp.

The filter is now tracking the pilot signal and will remain there until the presence of a true signal at the main loop input energizes relay K2.

d. TRUE SIGNAL ACQUIRED. - With relay K2 energized, relay contacts K2A energize relay K3 which connects the main phase detector to the equalizer (K3A) and grounds the pilot main phase detector (K3B). Contacts K2C provide a return to ground for the SIG lamp (green). Contacts K2B energize relay K5. Relay contacts K5A then open the relay K6 circuit and prevent relay K6 from energizing even upon drop-lock (pilot inhibit). To complete the transfer from pilot to signal mode, contacts K5C hold relay K5 energized via MEMORY switch S1A. Contacts K5D keep the memory enabled and contacts K5B ground the pilot input signal and cause relay K7 to de-energize. With relay K7 de-energized, contacts K7A disconnect the pilot main phase detector from the equalizer, contacts K7B prepare to energize relay K4 (automatic sweep), contacts K7C connect the CORRELATION meter to the main correlation amplifier, and contacts K7D extinguish the PLT lamp (green). The filter is now tracking the true signal in a normal manner.

e. DROP-LOCK. - Loss of input signal is reflected by zero output from the main loop correlation amplifier, which de-energizes K2. Relay K5, however, remains energized via holding contact K5C. With relay K2 de-energized, relay K3 is opened and relay K4 is closed. This reverts the loop to its pre-acquisition state, except that the sweep is now centered around the drop-lock frequency (memory still enabled by K5D); the main phase detector is disconnected from the equalizer (K3A), the internal sweep is started (K4A and K4B), and the SIG lamp glows yellow (K2C) indicating drop lock.

f. SIGNAL REACQUIRED. - Reacquisition of the input signal closes relay K2 and initiates a sequence similar to that described in subparagraph d of this procedure.

2-9. PILOT ACQUISITION IN AUTOMATIC MODE, MEMORY OUT.

To establish this mode, the SWEEP TIME control is rotated out of the MANUAL detent, the MEMORY switch is OUT, the SET/ACQ switch indicates SET, the SIG lamp glows yellow, and the PLT lamp is extinguished.

a. SET. - During the initial SET condition, all relays are de-energized. Relay contacts K3A hold the equalizer input open and contacts K3B ground the output of the main phase detector. The

output of the pilot main phase detector is grounded by relay contacts K7A. These conditions permit the filter to be tuned to establish a sweep center frequency in the vicinity of the pilot input.

b. ACQUIRE PILOT. - For pilot acquisition, the PLT/SIG switch is pressed to establish a pilot mode. This energizes relay K6 and results in the following action: the PLT lamp glows yellow and the SIG lamp is extinguished (K6D), the CORRELATION meter indicates the output of the pilot loop correlation amplifier (K6A), and relays K3 and K5 are prevented from energizing (K6D). With relays K3 and K5 de-energized, the tracking loop is open (K3A and K3B) and the pilot input is ungrounded (K5B). The SET/ACQ switch is then pressed to establish an ACQ mode. This energizes relay K1 and causes the ACQ lamp to glow yellow (memory out). Relay contacts K1A then energize relay K4 which starts the internal sweep (K4A and K4B) and disables the memory circuit (K4D). In addition, the pilot and main loop control circuits are closed by relay contacts K1C and K1D, respectively. The loop is now ready to acquire the pilot signal and the vco is being swept about the SET FREQUENCY control setting.

c. PILOT ACQUIRED. - The output of the pilot correlation amplifier energizes relay K7. With relay K7 energized, the pilot main phase detector is connected to the equalizer (K7A), relay K4 is de-energized, disabling the sweep (K7B), the CORRELATION meter is held at the output of the pilot correlation amplifier by contacts K7C, relay K6 is de-energized, and a ground return is provided for the PLT lamp (green) by contacts K7D. Relay contacts K6C prepare relays K3 and K5 for normal operation (acquisition of signal input). Relay contacts K6D extinguish the yellow PLT lamp illuminate the yellow SIG lamp.

The filter is now tracking the pilot signal and will remain there until the presence of a true signal at the main loop input energizes relay K2.

d. TRUE SIGNAL ACQUIRED. - With relay K2 energized, relay contacts K2A energize relay K3 which connects the main phase detector to the equalizer (K3A) and grounds the pilot main phase detector (K3B). Contacts K2C provide a return to ground for the SIG lamp (green). Contacts K2B energize relay K5. Relay contacts K5A then open the relay K6 circuit and prevent relay K6 from energizing. To complete the transfer from pilot to signal mode, contacts K5B ground the pilot input signal which causes relay K7 to de-energize. With relay K7 de-energized, contacts K7A disconnect the pilot main phase detector from the equalizer, contacts K7B prepare to energize relay K4 (automatic sweep), contacts K7C connect the CORRELATION meter to the main correlation amplifier, and contacts K7D extinguish the PLT lamp (green).

e. DROP-LOCK.- Loss of input signal de-energizes relay K2. Contacts K2A then de-energize relay K3 and energize relay K4. This action disconnects and grounds the main phase detector (K3A and K3B), starts the sweep (K4A and K4B), prepares the memory circuit for inhibit (K4D), switches the SIG lamp to yellow indicating drop lock (K2C), and de-energizes relay K5 (K2B). In the de-energized state, relay K5 prepares the loop control network for reacquisition of the pilot signal; the pilot input is ungrounded (K5B), the memory circuit is disabled (K5D and K4D closed), and relay

K6 is energized. With relay K6 energized, the following action results: the PLT lamp glows yellow and the SIG lamp is extinguished (K6D), the CORRELATION meter indicates the output of the pilot loop correlation amplifier (K6A), and relays K3 and K5 are prevented from energizing (K6C). The filter will now reacquire the pilot signal, lock on, and wait for the true signal as described in paragraph 2-8, c and d.

2-10. PILOT ACQUISITION IN MANUAL MODE, MEMORY IN OR OUT.

This mode of operation is essentially the same as pilot acquisition automatic mode, memory in (paragraph 2-8), except that in this case the sweep circuits are disabled (K4 circuit opened by switch S10 in MANUAL position).

Under these circumstances, it makes no difference whether the memory circuit is in or out, because the filter will remain at the last known frequency in the event of drop-lock. The difference in filter behavior as a function of the MEMORY switch is as follows (after drop-lock). With memory in, the filter can only reacquire the true signal and with memory out, the filter can only reacquire the pilot signal.

To establish this mode, the SWEEP TIME control is rotated into its MANUAL detent, the MEMORY switch is set as desired, and the SET/ACQ switch is at SET. The SET lamp glows red and the PLT lamp is extinguished.

a. SET. - During the initial SET condition, all relays are de-energized. Relay contacts K3A hold the equalizer input open and contacts K3B ground the output of the main phase detector. The output of the pilot main phase detector is grounded by relay contacts K7A. These conditions permit the filter to be tuned to establish an operating frequency in the vicinity of the pilot input.

b. ACQUIRE PILOT. - For pilot acquisition, the PLT/SIG switch is pressed to establish a pilot mode. This energizes relay K6 and results in the following action: the PLT lamp glows yellow and the SIG lamp is extinguished (K6D), the CORRELATION meter indicates the output of the pilot loop correlation amplifier (K6A), and relays K3 and K5 are prevented from energizing (K6D). With relays K3 and K5 de-energized, the tracking loop is open (K3A and K3B) and the pilot input is ungrounded (K5B). The SET/ACQ switch is then pressed to establish an ACQ mode. This energizes relay K1 and causes the ACQ lamp to glow green or yellow depending upon the setting of the MEMORY switch. Relay K1 then energizes the pilot and main loop control circuits by relay contacts K1C and K1D, respectively. The loop is now ready to acquire the pilot signal and the vco may be tuned by the SET FREQUENCY control until zero beat is observed on the CORRELATION meter.

c. PILOT ACQUIRED. - The output of the pilot correlation amplifier triggers relay K7. With relay K7 energized, the pilot main phase detector is connected to the equalizer (K7A), the CORRELATION meter is held at the output of the pilot correlation amplifier by contacts K7C, relay K6 is de-energized, and a ground return is provided for the PLT lamp (green) by contacts K7D. Relay contacts K6C prepare relays K3 and K5 for normal operation (acquisition of signal input). Relay contacts K6D extinguish the yellow PLT lamp and illuminate the yellow SIG lamp.

The filter is now tracking the pilot signal and will remain there until the presence of a true signal at the main loop input energizes relay K2.

d. TRUE SIGNAL ACQUIRED. - With relay K2 energized, relay contacts K2A energize relay K3 which connects the main phase detector to the equalizer (K3A) and grounds the pilot main phase detector (K3B). Contacts K2C provide a return to ground for the SIG lamp (green) and contacts K2B energize relay K5. Relay contacts K5A then open the relay K6 circuit and prevent relay K6 from energizing. To complete the transfer from pilot to signal mode, contacts K5B ground the pilot input signal and cause relay K7 to de-energize. With relay K7 de-energized, contacts K7A disconnect the pilot main phase detector from the equalizer, contacts K7C connect the CORRELATION meter to the main correlation amplifier, and contacts K7D extinguish the PLT lamp (green).

e. DROP-LOCK. - Loss of input signal de-energizes relay K2. Contacts K2A hold relay K3 on via the MANUAL position of switch S10. Contacts K2C cause the SIG lamp to glow yellow indicating drop-lock. If memory is out when drop-lock occurs, contacts K2B de-energize relay K5. In the de-energized position, relay K5 again prepares the loop control network for possible acquisition in the pilot mode, the pilot input is ungrounded (K5B), and the relay K6 circuit is prepared by contacts K5A for action in the pilot mode. If memory is in at the moment of drop-lock, K5 remains energized via K5C and switch S1. In this condition, contacts K5A disable relay K6 and contacts K5B ground the pilot input. The pilot mode can be established by either setting the MEMORY switch to OUT or returning to SET mode and repeating steps a and b. Note that the memory circuit is always effective in the manual acquisition modes (S10 holds relay K4 open, thus preventing contacts K4D from shunting the memory capacitor). This does not create a problem in reacquiring the signal because the SET FREQUENCY controls still permit the filter to be tuned. A problem of adequate SET FREQUENCY control range may be encountered, however, because the output of the equalizer is offset from zero and the SET FREQUENCY controls must conteract the offset. Should this not be possible, it will be necessary to return to the SET mode and reacquire in the normal manner. It is imperative that the main phase detector be carefully balanced when using the MANUAL mode. The loop is closed in manual, and phase detector offset is integrated by the equalizer network to produce a drift at the vco.

Section 3. DETAILED CIRCUIT ANALYSIS

2-11. INPUT MIXER/I-F AMPLIFIER 9460000 (MODULE X5).

a. GENERAL. - Input Mixer/I-F Amplifier 9460000 (figure 7-3) consists of an input mixer, a wide-band i-f amplifier, and a narrow-band i-f amplifier. The primary purpose of the input mixer is to produce an i-f signal. This is accomplished by heterodyning the input signal and the vco frequency in the mixer stage to develop a composite mixer output signal. The mixer signal is applied to the wide-band (120-kc) amplifier which amplifies both the translated carrier (250-kc) and any

modulation sidebands that may be present within the 120-kc bandpass. Overall bandwidth is further reduced by the narrow-band (2.5-kc) amplifier which furnishes the signal inputs to the main and auxiliary phase detectors.

b. INPUT MIXER. - The balanced input mixer circuit consists of transformer T1, diodes CR1 and CR2, potentiometer R6, and associated components. Potentiometer R6, capacitor C2, and matched diodes CR1 and CR2 serve to balance the circuit to reject the vco frequency. The input signal is applied across INPUT LEVEL ADJ potentiometer R1 with an adjustable portion being fed to the center arm of potentiometer R6 of the mixer circuit. The vco frequency is applied across the primary winding of transformer T1 to drive the circuit. The action of the mixer is essentially that of an electronic switch which alternately shorts the center arm of potentiometer R6 to ground, so the impedance level varies from about 1000 to 500,000 ohms. The waveform of the signal, as viewed at test point TP1 is essentially the input signal chopped at the vco frequency rate (see figure 2-2).

The entire mixer signal is applied to emitter-follower Q1, which drives untuned transformer T2. Transformer T2 is a step-down impedance matching transformer which is untuned so that the entire broad-band mixer signal is applied to the first i-f amplifier stage.

c. WIDE-BAND I-F AMPLIFIER CIRCUIT. - First i-f amplifier Q2 is a common-base amplifier biased by voltages applied through resistors R12, R13, and R14. The correlated agc voltage is applied through diode CR3, and a bias voltage from the agc scaling network is applied through diode CR4 to compensate for gain changes caused by selection of different bandwidths. A delayed agc is provided by supplying positive voltage to the circuit through resistor R13. The agc voltage draws current through diode CR5 which acts as a signal shunt across transistor Q2 input. The shunt impedance is a function of the diode current providing a control on the stage gain.

Transistor Q3 is a silicon npn power transistor which provides the amplification and power necessary to drive transformer T4. Bias for the stage is provided by a voltage divider consisting of resistors R17 and R18. The collector circuit of transistor Q3 is tuned in the primary of transformer T4 to establish the i-f bandwidth at exactly 120 kc. The wide-band i-f signal taken from the secondary of transformer T4 is routed through isolation resistors R31 and R32 to the correlated detector circuits in the phase detector module. From the collector of transistor Q3, the i-f signal is coupled through capacitor C17 and isolation resistor R21 to drive narrow-band i-f transformer T5.

d. NARROW-BAND I-F AMPLIFIER CIRCUIT. - The loaded Q of transformer T5 is approximately 100 to achieve the 2.5-kc bandwidth. The primary winding of transformer T5 is resonated by capacitor C19, and optimum tuning is accomplished by varying the inductance of the primary. The narrow-band i-f signal is applied through emitter-follower Q4 which provides impedance matching for driving power transistor Q5. Bias for transistor Q4 is furnished by a voltage divider consisting of resistors R23 and R24. Capacitor C20 and resistor R24 form a decoupling network for the base of transistor Q4. Similarly, the collector of transistor Q4 is decoupled by capacitor C21 and resistor R25.

Transistor Q5 is a silicon npn driver transistor. Bias is set by resistors R26 and R28; the transistor dissipates approximately 2 watts during quiescent periods. Because of the power dissipation, the transistor is mounted in a heat sink with the collector electrically and physically connected to the heat sink. The collector of transistor Q5 is tuned in the primary of transformer T6, and the narrow-band i-f signal is routed through resistors R34 and R36 to the main phase detector and auxiliary phase detector circuits. Resistors R33, R35, R37, and R38 are isolation resistors located in this module to minimize loading on the phase detectors. The i-f signals measured at TP2 and TP3 are 180 degrees out of phase with each other in order that crosstalk between amplitude-modulated and phase-modulated signals may be eliminated.

e. ADJUSTMENTS. - Potentiometer R1 is used to control the level of the input signal. Potentiometer R6 and capacitor C2 are used to balance the input mixer. Transformer T5 optimizes the phase shift relationships between the narrow and wide-band driver stages. Capacitors C2 and C13 do not normally require adjustment after leaving the factory. Detailed adjustment procedures are contained in chapter 5.

2-12. PHASE DETECTOR/REFERENCE OSCILLATOR ASSEMBLY 9461000 (MODULE X4).

a. GENERAL. - Phase Detector/Reference Oscillator Assembly 9461000 (figure 7-4) includes a reference oscillator, a main and an auxiliary phase detector, and accessory detector circuits. As employed in the Models PL300 - PL307 tracking filters, the reference oscillator is converted to an amplifier by the removal of 250-kc crystal CR5 and the insertion of capacitor C18. The primary purpose of the reference oscillator (amplifier) circuit is to make available the 250-kc switching signal required by the phase detectors. This signal is connected to the main phase detector through a 90-degree phase shifting network. Here the phase difference between this reference signal and the i-f signal is derived. The output of the main phase detector is applied to the equalizer amplifier where the phase difference is integrated to develop a direct current for driving the voltage controlled oscillator. The output of the auxiliary phase detector is used by the agc and correlation amplifiers for loop control.

b. REFERENCE OSCILLATOR (AMPLIFIER). - Tracking Filter Models PL300 - PL307 are provided with Reference Oscillator Assembly 9468000 (Module X10). This assembly, which is described in paragraph 2-25, makes available a 25-mc reference signal. This frequency is divided by 100 in special phase stable digital dividers and applied to the phase detector/reference oscillator assembly. With the removal of crystal CR5 and the addition of capacitor C18, transistor Q5 of the reference oscillator functions as a grounded base amplifier. The output of this transistor drives the tuned primary of transformer T3 which in turn drives three emitter followers (transistors Q2, Q4, and Q6). The reference signal to transistor Q2 (at the input to the main phase detector) is applied through the phase shifting network comprised of capacitors C8 and C9, and of inductor L1. Transistor Q4 drives the auxiliary phase detector, while the output of transistor Q6 is used by the x1 output mixer in the voltage controlled oscillator assembly.

c. MAIN PHASE DETECTOR. - The main phase detector consists of emitter-follower Q2, amplifier Q1, transformer T1, diodes CR1 and CR2, potentiometer R3, and associated components. The operation of the phase detector circuit in comparing the phase of the narrow-band i-f signal with the 250-kc reference signal is essentially the same as the input mixer discussed in paragraph 2-11. (See figures 2-2, 2-4, and 2-5.)

Capacitors C8 and C9, and coil L1 form a 90-degree phase-shifting network to shift the phase of the 250-kc reference signal 90 degrees at the base of transistor Q2 with respect to the 250-kc reference signal at the base of transistor Q4. Transistor Q2 is an emitter follower used to drive amplifier Q1. Resistors R7 and R11 form a voltage divider to bias the base of transistor Q2. Resistor R12 and capacitor C7 form a decoupling network for the emitter of transistor Q2. Transistor Q1 is a silicon npn driver transistor biased by a voltage divider consisting of resistors R6 and R9 so the transistor dissipates approximately 2.0 watts in its quiescent state. Capacitor C3 and choke L2 form a decoupling network for the collector circuit. Capacitor C4 tunes the primary of transformer T1 in order to ensure quadrature relationships between the main and auxiliary driver signals. All diodes used are special matched pairs with 300-volt peak inverse voltage ratings and very fast reverse recovery times.

d. AUXILIARY PHASE DETECTOR. - The main and auxiliary phase detectors are identical except for the phase of the 250-kc switching signal. The description given in the preceding paragraphs is, therefore, applicable to the auxiliary phase detector except for component designations.

e. ACCESSORY DETECTOR CIRCUITS. - Separate half-wave phase detector circuits are provided for the demodulators and pilot acquisition optional accessories. The opposite half cycle from that used by the basic phase lock loop in driving the main and auxiliary phase detectors is used because the desired exact phase relationships are maintained automatically. Extremely good electrical isolation is maintained between all detector circuits because all are balanced with respect to ground. In the case of the demodulator circuits, the phase detectors are more properly called correlated detectors. These are coherent or synchronous detectors whenever the signal-to-noise ratio is adequate to permit 100 percent correlation in phase between the input signal and the 250-kc reference signal.

f. ADJUSTMENTS. - For optimum filter operation, it is imperative that the main and auxiliary phase detectors be balanced for zero volts output under no-signal conditions. This is accomplished by proper adjustment of potentiometers R3 and R15, with voltage measurements taken at test points TP1 and TP4 or at their corresponding coaxial connectors on the rear of the chassis. The inductance of the 90-degree phase shifter coil L1 is also adjustable so the correct quadrature phase relationship can be realized between the two 250-kc phase detector driving signals. Coil L1 does not normally require adjustment after leaving the factory. Details of the phase detector balancing procedures are provided in chapter 5.

2-13. BANDSWITCH ASSEMBLY 9470000 (CARD X2).

Bandswitch Assembly 9470000 (figure 7-5) contains the majority of resistors used in the various bandwidth selection networks. The various bandwidths of the phase lock loop are controlled by switching resistances R_c, R_d, R_e, and R_f associated with frequency determining r-c networks. Similar bandwidth controlling feedback networks for the correlation amplifier in the loop control assembly (module X8) are mounted on this card in order to facilitate switching.

As shown in figure 2-6, the output from the main phase detector is introduced into the first (passive) integrator network R_c, R_d, and C_a, and the output from this circuit is fed to the input to the second (active) integrator via R_c. It should be noted that resistor R38 in the input mixer/i-f assembly (module X5) forms part of R_c; this location is provided in order to minimize capacitive loading on the phase detectors.

The remaining resistors on this plug-in card are associated with the ladder attenuator of the automatic sweep circuit. This attenuator network controls the triangular sweep voltage such that the sweep rate never exceeds the tracking bandwidth squared in cycles per second per second. Use of a constant impedance ladder network is required in order to minimize loop phase transients while switching bandwidths.

2-14. EQUALIZER AMPLIFIER ASSEMBLY 9462000 (MODULE X6).

a. GENERAL. - Equalizer Amplifier Assembly 9462000 (figure 7-6) contains a chopper-stabilized d-c amplifier used as an operational integrator. Bandwidth determining capacitors for both the passive and active integrators are also contained in this module. The amplifier output is applied to the vco driver stage where a control current is generated which is a function of the output of the main phase detector.

b. CIRCUIT ANALYSIS. - The input signal is applied to the junction of resistor R1 and capacitor C3 where the higher-frequency components are passed through capacitor C3 to transistor Q1a. Low-frequency components are passed by resistor R1, capacitor C13, and resistor R22 to the emitter of chopper transistor Q7.

Transitor Q7 may be considered a modulator, and transistor Q11 a demodulator. Transistors Q12 and Q13 form a 400-cps free-running multivibrator whose output is applied through capacitor C15 to the bases of transistors Q7 and Q11 to turn them on and off in parallel. Because transistor Q7 is the pnp type, the negative pulse output of the multivibrator forward biases it into saturation; the positive pulse drives it to cutoff, and the input signal is alternately shorted to ground at the 400-cps rate. During the half cycle in which transistor Q7 is at cutoff, it presents a high impedance and the input signal is coupled through capacitor C8 to directly coupled amplifier Q8.

Negative feedback for the directly coupled amplifier is provided by resistor R31, capacitor C9, and resistor R27. Resistor R23 provides a bias reference for transistor Q8, and resistor R28 provides degenerative feedback as well as increasing the input impedance of Q8. Diode CR3 provides a dynamic load for the emitter of transistor Q9 as do diodes CR4 and CR5 for transistor Q10, in addition to establishing the proper bias. The d-c amplifier inverts, amplifies, and routes the signal through capacitor C10 and resistor R34 to demodulator Q11. Because the signal is inverted, it can be demodulated by transistor Q11 in parallel with the modulating action of transistor Q7. The demodulated signal is applied across a long time-constant network, consisting of resistor R35 and capacitor C6, to the base of transistor Q1b. The long time-constant of the network removes the 400-cps drive frequency from the signal.

Dual transistor Q1 is a differential amplifier with the a-c component of the input signal at one base and the amplified d-c component at the other. The values of emitter resistor R5 and the two collector resistors, R2 and R6, are very large to minimize noise in the input stage; consequently, the gain of the stage is very low. Capacitor C4 and resistor R3 are a corner network to control the gain-bandwidth product of the amplifier. Dual transistor Q2 is also a differential amplifier with its bases connected to transistor Q1 and its collectors are connected to transistors Q3 and Q4. Transistors Q1 and Q2 are dual npn types selected for their extremely high beta, low noise figure, and matched V_{be} characteristics.

Transistors Q3 and Q4 are also connected in a differential amplifier configuration. Because of common-emitter resistor R12, signal variations at the base of transistor Q3 will be represented as voltage variations across emitter resistor R12. In transistor Q4, the voltage variations appearing across resistor R12 are summed with the voltage variations at the base of transistor Q4 to make the collector current of transitor Q4 a single ended representation of the total differential signal at the input to the differential amplifier. Because the emitter of transistor Q4 is connected to +15 volts through resistor R12 and the collector is connected to -15 volts through diode CR1 and resistor R14, a zero potential exists at some point in the circuit. The values of the resistors are chosen so that zero potential exists in the center of diode CR1. A bipolar signal can, therefore, be taken from across the diode to drive the complementary emitter-follower output stage. Because of the complementary emitter-follower configuration, the voltage at the junction of resistors R16 and R17 is the algerbraic sum of the currents through transistors Q5 and Q6. Capacitor C1 is the feedback capacitor for the active integrator and serves as the memory capacitor C_m when the relay logic opens the input circuit. Capacitor C14 is part of the first integrator section of the equalizer network.

c. ADJUSTMENTS. - The AMPL BAL potentiometer R26 is provided to balance the output of the equalizer amplifier to zero for zero input. CHOPPER FREQ potentiometer R46 permits adjustment for minimum switching transients. CHOPPER DRIVE test point TP1 and EQUALIZER OUTPUT test point TP2 are provided for monitoring their respective circuit outputs. Further details on making these adjustments are provided in chapter 5.

2-15. VCO DRIVER ASSEMBLY 9474000 (CARD X1).

a. GENERAL. - VCO Driver Assembly 9474000 (figure 7-21) contains a vco driver circuit, a phone amplifier circuit, and an agc scaling network. The vco driver circuit is controlled by the equalizer amplifier output voltage, by a voltage provided by the SET FREQUENCY control, by the signal from the sweep circuit, or by the sum of all of these. The output of the vco driver circuit is a d-c current used to control the inductance of the vco controllable inductor. The phone amplifies the beat frequency from the main phase detector for an aural aid to signal acquisition. Resistor R7 connects to the METER ZERO potentiometer and completes the circuit between -15 volts and ground.

b. AGC SCALER NETWORK. - Resistors R18, through R24 form a voltage divider between -15 volts and ground. A fixed amount of bias voltage, in addition to the correlated agc bias voltage is thus applied to the i-f amplifier for each position of the BANDWIDTH CPS switch. As seen in figure 7-21, the exact value of these resistors is individually selected to provide proper loop tracking bandwidths at the signal thresholds listed in table 1-6.

c. VCO DRIVER CIRCUIT. - Transistors Q1 and Q2 form the vco driver circuit. Transistor Q1 is connected in a common-base configuration to provide drive for transistor Q2. Resistors R1 through R4 are input gain resistors which isolate the signal sources. Test point TP1 provides a point from which external test voltages may drive the vco. Potentiometer R10 is used to adjust the frequency deviation range of the vco. Potentiometer R11 is used to position the zero frequency of the vco. Transistor Q2 develops the d-c current which controls the vco. Resistor R13 and thermistor TR1 provides bias stabilization for transistor Q2. Besides the d-c current used to drive the vco, the vco driver circuit furnishes the signal voltage used as the input to the analog frequency amplifier.

d. PHONE AMPLIFIER. - The phone amplifier consists of transistors Q3, Q4, and Q5. The input signal is coupled through capacitor C1 to transistor Q3, and the output signal is taken from capacitor C5. The values of coupling capacitors C1, C2, C3, and C5 are relatively large to accommodate the low frequency of the signal. Capacitors C4 and C6 provide emitter decoupling for the second and third amplifier stages.

e. ADJUSTMENTS. - The adjustments of potentiometers R10 and R11 are quite critical, however, they do not normally require adjustment after leaving the factory. Further details are provided in chapter 5.

2-16. VOLTAGE CONTROLLED OSCILLATOR ASSEMBLY 9463000-501 (MODULE X7).

a. GENERAL. - Voltage Controlled Oscillator Assembly 9463000-501 (figure 7-22) consists of a x100 vco, mixer, low-pass filter and video amplifier; a x10 mixer, low-pass filter and video amplifier; and a x1 mixer, low-pass filter and video amplifier. The x100 vco control current is

derived from the vco driver stage. The x100 vco output frequency (25 mc to 37 mc) is divided by ten and used as the x10 vco input signal. The x10 output frequency (2.5 mc to 3.7 mc) is divided by ten and used as the x1 vco input signal. The video amplifiers in this assembly provide the following output frequencies: input signal x100, input signal x10, and input signal x1.

b. VCO CIRCUIT (x100). - The x100 vco circuit (component board assembly 9463400) consists of a controllable inductor, transistor Q1, and capacitors C2, C3, C4, and C5 connected in a modified Colpitts oscillator configuration. Capacitor C2 and the secondary winding of the controllable inductor form the tuned circuit. Regenerative feedback to sustain oscillation is coupled through capacitor C3 to the junction of capacitors C4 and C5 which form a capacitive divider. The values of capacitors C4 and C5 are chosen to provide a loop gain slightly greater than unity.

The vco frequency is changed by varying the d-c current through the control winding of the controllable inductor which in turn changes the inductance of the secondary winding in the tuned circuit. The frequency range of the oscillator is linear (±5 percent), with respect to control winding current, over its entire range. The vco output is applied through capacitor C10 and isolation resistor R11 to mixer Q3, and through capacitor C6 to power amplifier Q2. Amplifier Q2 drives transformer T1 which supplies the signal input to the tracking filter's main loop.

c. MIXER AND VIDEO CIRCUITS (x100). - The 25-mc reference frequency is applied through isolation resistor R12 and capacitor C11 to the base of mixer Q3 where it is mixed with the vco output frequency. The amplitude of the vco frequency at the base of mixer Q3 is approximately five times greater than the amplitude of the reference frequency in order to achieve optimum low-level mixing action. Appreciable conversion gain is realized through the mixer stage which generates a composite signal consisting of the reference frequency, vco frequency plus reference frequency, vco frequency minus reference frequency, and vco frequency.

The output of the mixer stage is applied to emitter-follower Q4 which drives the low-pass filter network. Resistor R23 functions as an impedance matching resistor between the emitter-follower and the low-pass filter. The low-pass filter passes the vco frequency minus reference frequency component (input signal frequency) of the composite signal generated by the low-level mixer.

Transistor Q5 is the video amplifier provided to amplify the filtered signal. The stage utilizes three frequency compensation networks to maintain proper signal amplitude as the frequency varies. Resistor R26 and capacitor C22 tend to increase the gain of the stage as the frequency increases to compensate for rolloff. Coil L6 and resistor R28 perform the same function as coil L2 and resistor R16 in the mixer stage, that is, high-frequency peaking. Capacitor C24 and coil L7 form a video peaking network which keeps the response essentially flat over the desired frequency range. The output of transistor Q5 is fed to transistors Q6 and Q7 which provide the x100 output signal drive.

d. MIXER AND VIDEO CIRCUITS (x10). - The input signals applied to the x10 mixer stage Q1 on board assembly 9463500 are a 25-mc reference frequency divided by ten (2.5 mc) and the x100 vco output signal divided by ten (2.5 mc to 3.7 mc). The operation of these circuits is identical to that of the x100 circuits, except that high-frequency compensation networks are not needed because of the lower frequencies.

e. MIXER AND VIDEO CIRCUITS (x1). - The input signals applied to the x1 mixer circuit are the 250-kc reference frequency and the x10 vco output signal divided by ten. The x10 vco output signal divided by ten is also processed by buffer stage Q6 and made available at a coaxial connector at the rear of this chassis. The operation of these circuits in producing the x1 output is identical to that of the x10 circuits.

2-17. LOOP CONTROL ASSEMBLY 9464000 (MODULE X8).

a. GENERAL. - Loop Control Assembly 9464000 contains component board assemblies 9464100 and 9464200 (figure 7-7). Component board 9464100 consists of the agc and correlation amplifiers. Component board 9464200 consists of the loop control threshold and sweep drive circuits and the sweep amplifier. The correlation and agc amplifiers receive their input signals from the auxiliary phase detector via input gain resistors R35 and R33 in the input mixer/i-f assembly.

The loop control threshold circuits are energized by the output of correlation amplifier whenever the output reaches approximately 7-1/2 volts, either plus or minus. The output of the loop control circuit activates loop control relay K2.

When the automatic sweep is activated, the square wave output of the sweep drive circuit is fed to the input of the sweep amplifier which is essentially an operational integrator whose feedback loop is through capacitor C4. Because the sweep amplifier functions as a nearly perfect integrator, it converts the square wave to a triangular wave which is used to drive the vco when the tracking filter is in a search mode.

b. COMPONENT BOARD 9464100.

(1) AGC AMPLIFIER. - The input signal from resistor R33 in the input mixer/i-f assembly is applied to the base of Q1a (figure 7-7, sheet 1). Transistor Q1 is connected in a differential amplifier configuration with the base of the Q1a biased to ground by resistor R5, and the base of the Q1b biased by a voltage divider consisting of resistor R1, potentiometer R2, and resistor R3. Resistors R1 and R3 drop the voltage,and the current through them is routed to ground through diodes CR1 and CR2. The diodes are then forward biased and provide a small d-c voltage across potentiometer R4 that is used as the d-c zero reference. The value of resistor R4 is selected to provide matched input impedances at both bases of transistor Q1. To the degree that this identical relationship is sustained, both halves of transistor Q1 will be balanced as temperature changes occur. Capacitor C1 by-passes to ground any high-frequency pickup that may be present at the base of the reference side. Capacitor C2 is used to roll off the frequency response of the amplifier so that transistor Q2 essentially sees direct current.

Transistors Q2 and Q3 form the second differential input amplifier stage. The output of transistor Q3 is coupled into the emitter circuit of transistor Q2 via common-emitter resistor R10. Therefore, transistor Q2 develops a single-ended output across resistor R11 which is fed to the base of transistor Q4.

Transistors Q4 and Q5 are connected in a complementary symmetry configuration with transistor Q5 presenting a dynamic and complementary load to the collector of transistor Q4. The bias of transistor Q5 is held constant by a voltage divider consisting of resistors R12 and R13. The collector current path for transistor Q4 from +15-volt supply is through resistor R16, transistor Q5, parallel connected diodes CR3 and CR4, and resistor R15 to the collector of transistor Q4. Because the emitter of transistor Q4 connects to -15-volts, the center of diodes CR3 and CR4 can be considered zero potential, and the forward voltage drop across CR3 and CR4 provides a small forward bias on both transistors Q6 and Q7 reducing crossover distortion in the complimentary stage. Positive feedback is accomplished through resistor R14 by adjusting the dynamic load, transistor Q5, so as to boost the gain of transistor Q4 to ensure overall amplifier gain greater than 10,000.

(2) CORRELATION AMPLIFIER. - This amplifier is identical to the agc amplifier except for the addition of a feedback network consisting of capacitor C6 and resistor R28, to give a 100-cps high-frequency rolloff. The effective value of capacitor C6 is changed through the action of the BANDWIDTH CPS switch by adding capacitance to reduce the corner frequency of the amplifier in direct relationship to the bandwidth being used by the tracking filter.

The correlation amplifier monitors the beat frequency between the reference and the input signal as the tracking filter is tuned to the vicinity of the input frequency. The amplitude of the correlation amplifier output increases as the beat frequency decreases, until the output voltage is sufficient to trigger the loop control threshold circuit. At drop-lock, the amplifier output falls off again. This is sensed by the threshold circuit which then permits loop control relay K2 to de-energize.

c. COMPONENT BOARD 9464200.

(1) LOOP CONTROL CIRCUIT. - When the output of the correlation amplifier reaches an amplitude of 7-1/2 volts, either plus or minus, the loop control threshold circuit (figure 7-7, sheet 2) is activated. Assume that a 7-1/2-volt negative-going signal is applied at module X8, pin 3. This amplitude will pass sufficient current through diode CR7 and relay K1 to turn off transistor Q9. The current path from diode CR7 to the base of transistor Q9 is through connector pin 1, closed contacts of relay K1, and back through connector pin 8. Now, assume a 7-1/2-volt positive-going input signal at connector pin 3. Transistor Q8 will shut off and current will be routed through resistor R24 and diode CR8 to the base of transistor Q9 through the same path as a negative-going input signal. In both cases, the signal applied to the base of transistor Q9 is negative-going.

Transistor Q9 and Q10 form a monostable multivibrator. In the quiescent state, transistor Q9 is biased to saturation and transistor Q10 to cutoff. The negative-going signal reverse biases transistor Q9 and changes the state of the multivibrator. With transistor Q10 now conducting, the voltage developed across the voltage divider, resistor R28 and diode CR10, changes the bias level on transistor Q11 from approximately +0.2 volt to -0.2 volt. Transistor Q11 is now forward biased

into conduction and it in turn energizes loop control relay K2. Diode CR12 is across the coil of the loop control relay to dampen spike voltages which might affect the operation of relay K2. Diode CR9 stablizes the voltage at the base of transistor Q10 when Q9 is conducting.

(2) SWEEP DRIVE AND SWEEP AMPLIFIER CIRCUITS. - (Figure 7-7, sheet 2; figure 7-8, and figure 7-25.) The sweep drive circuit consists of transistors Q12 and Q13 connected as a special multivibrator. In the automatic mode and with the loop control relay de-energized, the multivibrator produces a 20-volt peak-to-peak square wave output symmetrical about zero for the input to the sweep amplifier. The sweep amplifier is an operational amplifier electrically identical to the agc amplifier discussed in paragraph 2-17b. Feedback capacitor C4 and the SWEEP TIME potentiometer together with resistor R37 cause the amplifier to operate as an integrator.

To understand the sweep drive circuit, assume an initial state with transistor Q13 conducting. Current will flow through resistors R34 and R33 to the -15-volt supply, making the junction of resistors R34 and R33 more positive than -15 volts. This condition will forward bias transistor Q12 and current from the +15-volt supply will flow through resistors R31 and R32 and transistor Q12 to the -15-volt supply. The -10 volts at the junction of resistors R31 and R32 is applied through resistor R36 and holds transistor Q13 forward biased. From this it can be seen that both transistors Q12 and Q13 are conducting. Resistor R37 couples the negative potential appearing at the junction of resistors R31 and R32 out through pin 2 via the SWEEP TIME potentiometer to the sweep amplifier input.

The action of the sweep amplifier is that of an inverting integrator in that the output will increase linearly in a positive direction with a constant negative input. Zener diodes CR5 and CR6, however, limit the output ramp at 6.8 volts, the break-down voltage of the Zener diodes. When Zener diode CR6 breaks down, the current through it develops a positive voltage on the base of transistor Q13 (limited by diode CR11) and reverses the process previously mentioned. Transistors Q12 and Q13 are now reverse biased to cutoff and +10 volts is coupled to the input of the sweep amplifier. The output of the sweep amplifier is a triangular shaped waveform whose frequency is a function of the voltage levels produced by the sweep drive circuit, the setting of the SWEEP TIME control, and the breakdown voltage of the back-to-back Zener diodes. Proper voltage levels at a constant impedance are supplied to the vco driver summing junction by means of attenuating networks controlled by BANDWIDTH CPS switch S9.

d. ADJUSTMENTS. - The AGC BAL potentiometer R2, SWEEP BAL potentiometer R3, and CORR BAL potentiometer R22 are used to balance their respective amplifiers. Details on the proper adjustment procedures are discussed in chapters 4 and 5.

2-18. RELAY BOARD ASSEMBLY 9451600.

Relay Board Assembly 9451600 (figure 7-23) contains the seven relays used in the tracking filter. The tracking filter relay logic is discussed in detail in section 2 of this chapter.

2-19. POWER SUPPLY.

General descriptive and maintenance information for the power supply employed in the tracking filter is contained in an appendix to this instruction manual.

2-20. CALIBRATION OSCILLATOR BOARD 9451800.

Calibration Oscillator Board 9451800 (figure 7-10) consists of a 20-kc crystal oscillator with a clipping circuit in its output. The clipping circuit distorts the sine wave output to provide a signal rich in 20-kc harmonics for rapid checkout of the tracking filter.

The 20-kc crystal, transistor Q1, choke L1, and capacitor C2 form the oscillator circuit. The sine wave output is clipped by diode CR1, filtered by capacitor C6 and choke L2, and applied to the input mixer/i-f amplifier via the CAL position of the CAL/AGC switch for use as an internal calibrating signal. For the oscillator to operate, the CAL/AGC switch must be in the CAL position because the emitter of transistor Q1 is grounded by the switch.

Resistor R1 and capacitor C1 form a decoupling network to keep the 20-kc signal out of the power source. Resistor R8 biases the base of transistor Q1. Resistor R11 provides isolation in the line between the external calibration connector and the EXT CAL position of the CAL/AGC switch. Capacitors C4 and C5, and resistors R3 and R4 couple a 60-cps modulation signal for checkout of the demodulator circuits.

2-21. PILOT ASSEMBLY 9467000 (MODULE X3).

a. GENERAL. - Pilot Assembly 9467000 (figure 7-12) consists of a pilot mixer, i-f amplifier, pilot correlation amplifier, and pilot loop control circuit. The functional operation of the individual pilot circuits is essentially the same as their counterparts in the tracking filter main loop, in that they condition the main loop to lock on to an input frequency.

The pilot input signal appearing on the wiper of potentiometer R5 is mixed with the vco signal on the primary of transformer T2. (Refer to paragraph 2-11 for the input mixer discussion.) The combination of transformer T2, capacitor C1, diodes CR1 and CR2, and resistors R6, R7, and R5 comprise a balanced mixer. Mixer balance potentiometer R5 and adjustable differential capacitor C1 provide reactive balance compensation to eliminate the vco drive frequency. The mixed signal is transformer coupled to broad-band i-f amplifier Q1, which is tuned to 250 kc by coil L1 and capacitor C5. The 250-kc output of the i-f amplifier is coupled through resistors R18 and R12 to the pilot portions of the main and auxiliary phase detectors. Resistor R14 couples the auxiliary phase detector signal to the pilot correlation amplifier. The pilot correlation amplifier, composed of transistors Q2 through Q8 and their associated circuits, is identical in operation to the main loop correlation amplifier (paragraph 2-17), in the loop control assembly.

The output signal from the pilot correlation amplifier triggers the pilot loop control threshold circuit with a 7.5-volt signal either positive or negative. The operation of this loop control is identical to that of the main loop control (paragraph 2-17).

b. ADJUSTMENTS. - Potentiometer R1 is used to control the level of the incoming signal. Potentiometer R5 and capacitor C1 are used to balance the input mixer. The pilot correlation amplifier is balanced with potentiometer R10. Detailed adjustment procedures are contained in chapter 5.

2-22. DEMODULATOR AMPLIFIER ASSEMBLY 9465000 (MODULE X9).

a. GENERAL. - Demodulator Amplifier Assembly 9465000 (figure 7-13) contains two identical video demodulator amplifiers to provide amplification of amplitude and phase-modulation data extracted from the i-f signal. Signal detection is provided by synchronous demodulators in the phase detector/reference oscillator module. Associated with each amplifier circuit is a separate front panel controlled low-pass filter (figures 7-14 and 7-15) which removes unwanted high-frequency products generated by the demodulators.

b. VIDEO AMPLIFIERS. - Because both amplifiers are identical except for component designations, only the p-m amplifier will be discussed in this paragraph. The output of the p-m detector in the phase detector/reference oscillator assembly is transmitted to the demodulator assembly through an input emitter follower designed to minimize capacitive loading on the output circuit. This is accomplished by connecting the demodulator signal, on the center conductor of a coaxial cable, to the base of the emitter follower (transistor Q1a in figure 7-13). The coaxial cable shield is then connected to the emitter of the same transistor. This shield, the other end of which remains unterminated, then follows the fluctuations on the center conductor, thus effectively eliminating cable capacitance. A second emitter follower, transistor Q1b, drives the variable demodulator low-pass filter, the output of which is returned to the video amplifier in the demodulator assembly.

Transistor Q2 is a dual npn transistor connected in a differential amplifier configuration. Bias voltage for the input side is furnished by a voltage divider consisting of resistor R4, potentiometer R5, and resistor R6. Resistors R4 and R6 drop the voltage, and the current through them is routed to ground through diodes CR1 and CR2. This forward biases the diodes which provides a small voltage across potentiometer R5 that is used to control the quiescent current in transistor Q2 to provide zero-volt amplifier output for zero-volt amplifier input. Resistor R16 is the collector load for the stage, and resistor R9 is the common-emitter resistor. The signal developed across resistor R16 is the driving signal for transistor Q3.

Because transistor Q4 is an npn transistor with its voltage bias held constant by resistors R11 and R15 and its emitter current controlled on the output through resistor R17, it presents a dynamic load to the collector current of transistor Q3. The collector current path is from +15 volts through diode CR3, transistor Q3, diode CR4, transistor Q4, and resistor R18 to the -15-volt power supply.

Because the circuit is connected between +15 volts and -15 volts, zero potential exists at some point in the circuit. The component values have been chosen so zero potential exists at the center of diode CR4 and a small forward bias is applied to both transistors Q5 and Q6. The signals applied to the bases of transistors Q5 and Q6 are in phase, and the output at the junction of resistors R20 and R21 is created by the difference between the two collector currents. Capacitor C3 is connected between the base of transistor Q3 and the output to suppress high-frequency parasitic oscillation in the feedback loop. Feedback is routed through resistor R17 to the emitter of transistor Q4 to enhance the voltage gain of the amplifier.

A negative d-c voltage feedback path is provided around the video amplifier through resistor R22 and transistor Q2b. As the base of transistor Q2a swings positive, the output swings positive. The portion of the output fed back to the base of transistor Q2b causes this point to swing positive, and degeneration is accomplished in the differential stage (transistor Q2) by common mode rejection. A high-frequency cutoff is provided for the amplifier via capacitor C2 and resistor R10, also by means of common mode rejection. For frequencies high enough to be passed by capacitor C2 and resistor R10, both bases of transistor Q2 move in the same direction causing degeneration. Degeneration rather than total common mode rejection is realized in both of the preceding examples because a smaller amplitude is applied to transistor Q2b base than is applied to transistor Q2a base.

c. ADJUSTMENTS. - The amplifier balance potentiometers R5 and R27 are discussed in detail in chapter 5.

2-23. ANALOG FREQUENCY AMPLIFIER ASSEMBLY 9469000 (MODULE X13).

a. GENERAL. - Analog Frequency Amplifier Assembly 9469000 (figure 7-11) is driven from the vco control current generated in the vco driver. At the output of the amplifier, +10 volts corresponds to 0 kc, 0 volt to 60 kc, and -10 volts to 120 kc.

The analog frequency amplifier is identical to the agc amplifier discussed in paragraph 2-17, except that here a high degree of negative d-c feedback (resistor R8) is employed.

b. ADJUSTMENTS. - The FREQ ANAL BAL potentiometer R3 is used to adjust the amplifier for zero output with the filter locked onto a 60-kc calibrating signal.

2-24. DIVIDER ASSEMBLY 9466000 (MODULES X11 and X12).

a. GENERAL. - Divider Assembly 9466000 (figure 7-16) consists of basic component board assembly 9466100 and four divider subassemblies (figures 7-17 through 7-20). Two divider assemblies are employed in the tracking filter. One, module X11, is used to divide the 25-mc reference frequency down to 2.5 mc and 250 kc for use as the reference signal applied to the x10 and x1 vco mixer circuits. The other divider, module X12, is used to divide the x100 vco output for application to the main loop, to the x10 vco mixer circuit, and to the x1 vco mixer circuit.

b. COMPONENT BOARD ASSEMBLY 9466100. - The input signal, which has an amplitude of 2 volts peak-to-peak, is applied through connector pin 1 and coupling capacitor C1 to amplifier Q1. The collector of the amplifier is tuned by coil L1 and stray capacity, with resistor R3 shunting the tuned circuit to increase bandwidth. Coil L1 is adjusted so the tuned circuit appears inductive. The amplitude at the output of amplifier Q1 therefore rises as the frequency increases (25 mc to 37 mc) to provide reliable triggering for the N/5 circuit.

The output of the high-frequency N/5 circuit feeds directly into the high-frequency N/2 circuit to give an overall frequency division of ten. The output signal, 2.5 mc to 3.7 mc, is applied across resistor R5 to emitter-follower Q2 which provides the x10 output at connector pin 3. Resistor R5 increases the emitter-follower input impedance as seen by the high-frequency N/2 circuit.

The output of the high-frequency N/2 circuit is also applied across a signal conditioning network, resistor R8, and coil L2,to the low-frequency N/5 circuit. Coil L2 is adjusted to provide a rising signal amplitude with an increase in frequency to ensure reliable triggering for the low-frequency N/5 circuit. The N/5 and N/2 circuits provide an overall frequency division of ten which results in an output frequency range of 250 kc to 370 kc. The output of the N/2 circuit is a symmetrical square wave amplified by transistor Q3.

c. DIVIDER SUBASSEMBLY 9466700-501 (HIGH-FREQUENCY, N/5). - The high-frequency N/5 divider (figure 7-19) is a high-speed flip-flop with a special 3:2 steering network which enables the flip-flop to perform a divide-by-five function. The -15-volt power source is fed into the divider through dropping resistor R1, and the +15-volt power source is fed through dropping resistor R14. This results in -6 volts and +5 volts, respectively, being applied to the components of the divider. Resistor R1 and capacitor C1, and resistor R14 and capacitor C8 also serve to isolate the divider circuit signals from the -15-volt and +15-volt power sources.

As previously mentioned, the input signal has a characteristic rise in amplitude in proportion to its increase in frequency. The input signal is applied through capacitors C4 and C6 and the respective steering networks to the bases of both transistors. The time constant of resistor R9 and capacitor C5 permits transistor Q2 to conduct for three cycles of the input signal and then turn off. Transistor Q1 is then permitted by the time constant of resistor R6 and capacitor C2 to conduct for two cycles of the input signal and then turn off. This action results in a rectangular output signal whose period is 5 times that of the input period. The amplitude of the output signal is approximately 4 volts peak-to-peak.

d. DIVIDER SUBASSEMBLY 9466700 (HIGH-FREQUENCY, N/2). - The high-frequency, N/2 divider (figure 7-17) is a high-speed binary flip-flop. As discussed in subparagraph c, resistors R1 and R2 are provided to drop the +15 volts and -15 volts to +5 volts and -6 volts, respectively, for the transistors. The input signal is applied through capacitors C2 and C4 and the respective steering networks to the bases of the transistors. In this case, the time constants of resistor R8/capacitor C3, and resistor R5/capacitor C1 are identical; and the steering circuit is

arranged to provide the conventional flip-flop division by two. The output waveform is a square wave with an amplitude of approximately 4 volts peak-to-peak.

e. DIVIDER SUBASSEMBLY 9466700-502 (LOW-FREQUENCY, N/5). - The low-frequency N/5 divider (figure 7-20) is a high-speed flip-flop with a special 3:2 steering network which enables the flip-flop to perform a divide-by-five function. This circuit operates in the same manner as the high-frequency N/5 flip-flop discussed in subparagraph b. The frequency handling requirement of this flip-flop is 1/10 the high-frequency N/5 flip-flop; therefore, the component values are appropriately adjusted.

f. DIVIDER SUBASSEMBLY 9466700-500 (LOW-FREQUENCY, N/2). - The low-frequency N/2 divider (figure 7-18) is a high-speed conventional binary flip-flop. This circuit is identical to the high-frequency N/2 flip-flop discussed in subparagraph d except for certain component values.

2-25. REFERENCE OSCILLATOR ASSEMBLY 9468000 (MODULE X10).

Reference Oscillator Assembly 9468000 (figure 7-9) consists of transistor Q1, crystal CR1, transformer T1 and associated components. The oscillator is basically a common-base amplifier with regenerative feedback through crystal CR1 which is connected in a series mode configuration. Series mode is characterized by very low impedance at resonance, in this case 25 mc. Transformer T1 and capacitor C4 form the collector tuned load at 25 mc. Because crystal CR1 and the tuned circuit are resonant at the same frequency, the oscillator has very high gain at 25 mc.

In order to preserve the high gain of the tuned circuit, another secondary winding on transformer T1 is used to couple the 25-mc signal to the base of emitter-follower Q2. Emitter-follower Q2 has a very high input impedance and a relatively low output impedance to provide isolation between the oscillator and amplifier Q3. Power amplifier Q3 has a tuned collector circuit to provide maximum gain at 25 mc.

In the oscillator stage, resistor R3 is an emitter biasing resistor. The combination of resistors R1 and R2 forms a resistive divider which effectively biases transistor Q1 in a class A region. Capacitor C1 shunts the base thereby giving transistor Q1 a common base configuration.

NOTES

Chapter 3

INSTALLATION INSTRUCTIONS

3-1. UNPACKING AND HANDLING.

When installing the tracking filter, extreme care should be exercised, both in the interest of personnel safety and to prevent damage to the equipment. Set the carton in the correct position for opening; open it, and remove the contents. Check the contents of the carton against the packing list and table 1-2 of this manual.

3-2. INSPECTION.

The tracking filter has been thoroughly tested and inspected prior to shipment, and is ready for use when received. Upon receipt of the tracking filter, check the instrument for any obvious damage received in transit. If there is any apparent damage, immediately file a claim with the carrier. Refer to the warranty page in this manual to file a claim for damage in shipment.

3-3. MOUNTING PROCEDURE.

a. ENVIRONMENT. - Before starting the actual installation, refer to the outline drawing, figure 1-2, so that provisions can be made for minimum operating clearances. *The maximum ambient temperature for this equipment is 55^{o} C (130^{o} F).* Operation at temperatures in excess of this value may result in permanent component damage. The tracking filter is equipped with slides and is designed for rack mounting.

No special shielding is required although operating the unit in close proximity to high-strength, low-frequency magnetic fields should be avoided because this may adversely affect the vco performance.

Disconnect the slide rails from the slides and install the rails in the rack. Pay particular attention to the rail adjustments (figure 1-2) necessary to give proper clearances. Install the two thumb screws, found in the accessory package, into the holes provided in the front panel.

b. POWER REQUIREMENT. - The tracking filter is wired to operate from a 115-volt, 50 to 400 cps power source. For protection of operating personnel, this unit is equipped with a three-conductor power cable, which, when plugged into an appropriate receptacle, grounds the unit. The center pin of the Hubbel power connector at the rear of the chassis is the ground pin. *Instructions for power supply conversion to 210-250-volt d-c operation are contained in the appendix to this manual.*

c. CABLING. - Coaxial connectors are provided on the rear of the chassis for connecting input and output signals to other equipment. Type RG 58/U coaxial cable should be used in fabricating cables; the cables should be the shortest length necessary to interconnect the equipment. *In rack mounted installations, however, sufficient cable length should be provided to accommodate a service loop so that the tracking filter can be pulled out and tilted on its slides.*

Chapter 4

OPERATING INSTRUCTIONS

This chapter contains information intended to enable operating personnel to comply with correct operating procedures. The information presented is divided into three sections. Section 1 provides general information on the use of the mode controls. Section 2 contains a preoperational checkout procedure to be used following installation, and prior to operating the tracking filter after extended shut down or maintenance periods to verify correct operation. Section 3 gives setup and signal acquisition procedures which enable operating personnel to prepare the tracking filter to acquire and track the input frequency.

Section 1. INTRODUCTION TO OPERATION

4-1. CONTROLS, INDICATORS, AND CONNECTORS.

Front panel operating controls and indicators for the tracking filter are illustrated and briefly described in figure 4-1. In figure 4-2, the input and output connectors at the rear of the chassis are illustrated and described.

Table 4-1 provides a summary description of tracking filter operation. All possible operating modes are listed, along with the requisite control settings for each.

4-2. SUMMARY OPERATING PROCEDURE.

a. GENERAL. - The various operating modes of the tracking filter are established by means of four controls designated SWEEP TIME, SET/ACQ, PLT/SIG, and MEMORY. These controls are used for determining the mode of signal acquisition and for status reporting of the selected operational mode. The acquisition modes are manual, automatic, and pilot manual or automatic. Familiarity with the purpose and use of these controls will provide greater efficiency in operating the tracking filter.

b. SWEEP TIME CONTROL. - The SWEEP TIME control serves three purposes; it selects manual or automatic mode of operation, and permits a continuously variable adjustment of sweep

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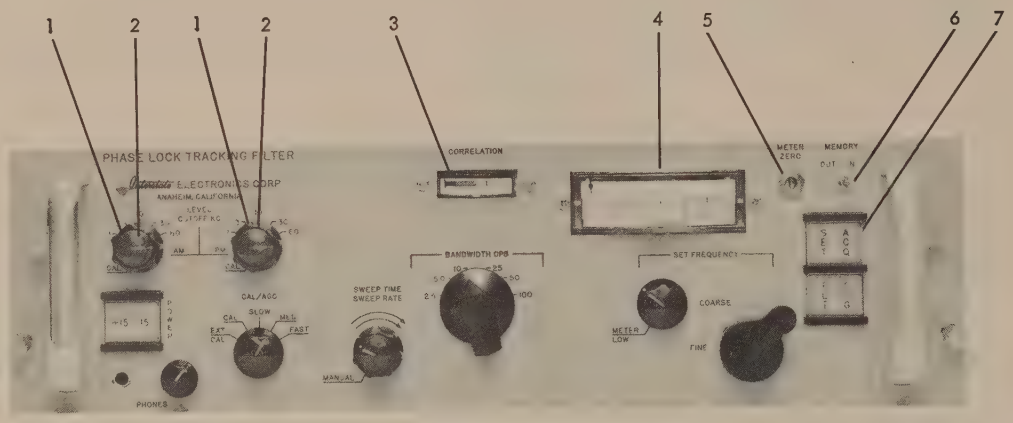

KEY

DESCRIPTION

1. The AM and PM CUTOFF KC rotary switches select bandwidths of 1, 3, 10, 30, or 60kc for the correlated a-m and p-m demodulators.

2. The AM and PM LEVEL controls permit continuous adjustment of the a-m and p-m demodulators output level. The CAL positions provide internal calibration signals approximately 30% of 60-cps modulation for demodulator checkout. (Use the 20-kc internal calibration signal for this check.)

3. The CORRELATION meter is used to monitor correlation between the i-f and reference signals.

4. The FREQUENCY meter displays the frequency to which the filter is tuned. The top scale covers frequency range 0 to 120 kc, and the lower scale covers 0 to 24 kc.

5. The METER ZERO potentiometer adjusts the FREQUENCY meter calibration.

6. The MEMORY switch enables or inhibits the memory circuit for retaining the last known frequency in the event of signal drop-out. In OUT position the ACQ lamp glows yellow, and in IN position, the ACQ lamp glows green.

7. The SET/ACQ switch, in SET position, permits manual tuning of the filter in open-loop mode. In the acquire mode, the SET lamp extinquishes and the ACQ lamp glows green or yellow depending on whether the MEMORY switch is in the IN or OUT position. The input signal cannot be acquired in the SET mode.

Figure 4-1. Phase Lock Tracking Filter Model PL307, Controls and Indicators (Sheet 1 of 2)

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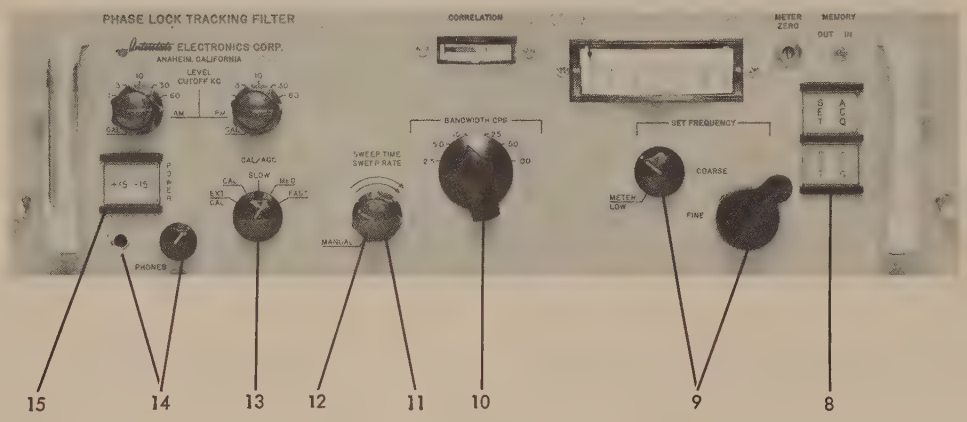
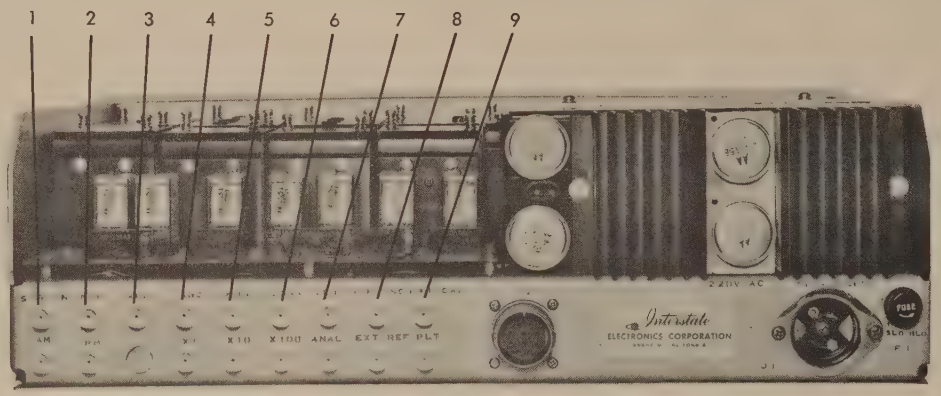


KEY	DESCRIPTION
8.	The PLT/SIG switch/indicator, in PLT position, permits pilot acquisition of the input signal. Under pilot control, the CORRELATION meter monitors the phase relationship of the pilot signal and the loop reference; when the input signal crosses the pilot frequency, phase-lock occurs automatically. The PLT lamp then extinquishes and the SIG lamp glows green to indicate true signal lock-on. The SIG lamp remains yellow if the true signal is not acquired.
9.	The COARSE and FINE SET FREQUENCY potentiometers adjust the vco frequency. The METER LOW position activates the 0 to 24 kc meter range.
10.	The BANDWIDTH CPS rotary switch establishes the phase-lock noise bandwidth at 2.5, 5.0, 10, 25, 50, and 100 cps.
11.	The SWEEP TIME switch/potentiometer provides sweep time adjustment from 0.3 to 10 seconds. The MANUAL switch position transfers signal acquisition from automatic sweep to manual.
12.	The SWEEP RATE potentiometer provides adjustable sweep rate up to a maximum of dial bandwidth squared cycles/sec/sec.
13.	The CAL/AGC rotary switch selects an external or internal calibration source for unit checkout. It also selects slow, medium, or fast time constants for the agc network when acquiring or tracking an input signal.
14.	The front-panel PHONES jack and potentiometer provide an aural aid to signal acquisition.
15.	The POWER switch controls application of primary power to the filter. The indicator lamps glow to confirm presence of secondary power (+15 and -15 volts).

Figure 4-1. Phase Lock Tracking Filter Model PL307, Controls and Indicators (Sheet 2 of 2)

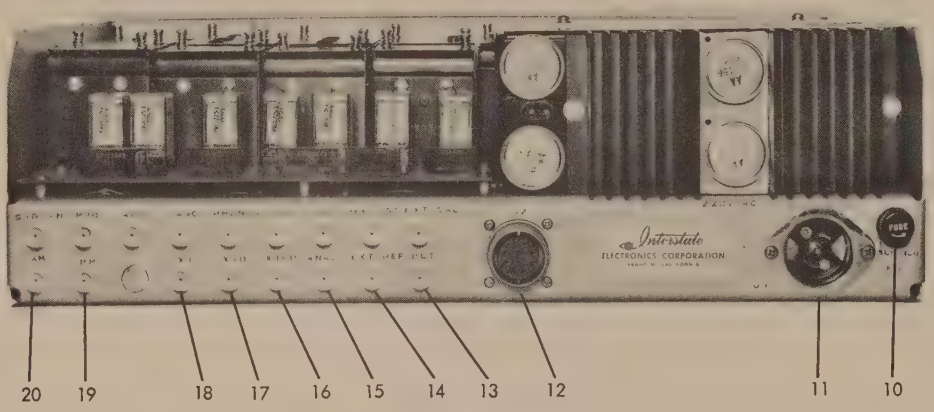
N500-156/A5871



KEY	DESCRIPTION
1.	The SIG IN coaxial connector provides an input connection for the signal to be tracked.
2.	The MPD coaxial connector provides a connection for monitoring the output of the main phase detector.
3.	The APD coaxial connector provides a connection for monitoring the output of the auxiliary phase detector.
4.	The AGC coaxial connector provides an output connection for the agc voltage.
5.	The PHONES coaxial connector is connected in parallel with the front-panel PHONES jack; it provides an output for recording the beat frequency between the i-f signal and reference frequency.
6.	The CORR coaxial connector provides a connection for recording the output of the correlation amplifier.
7.	The VCO coaxial connector provides a connection for monitoring the vco frequency applied to the input mixer.
8.	The REF OSC coaxial connector provides a connection for monitoring the 250-kc reference frequency.
9.	The EXT CAL coaxial connector provides an input connection for applying a back-up signal.

Figure 4-2. Phase Lock Tracking Filter Model PL 307, Input and Output Connectors (Sheet 1 of 2)

N500A156/A5871



KEY	DESCRIPTION
10.	The FUSE provides overload protection for the circuits of the tracking filter.
11.	Connector J1 provides an input connection for primary power.
12.	A set of contacts on the correlation relay terminate at connector J2 to provide a switch closure at the instant of signal acquisition which can be used to energize associated equipment.
13.	The PLT coaxial connector provides an input connection for a pilot frequency.
14.	The EXT REF coaxial connector provides an input connection for an externally applied 25-mc reference frequency.
15.	The ANAL coaxial connector provides an output connection for the frequency analog.
16.	The X100 coaxial connector provides an output connection for the X100 vco signal.
17.	The X10 coaxial connector provides an output connection for the X10 vco signal.
18.	The X1 coaxial connector provides an output connection for the X1 vco signal.
19.	The PM coaxial connector provides an output connection for the p-m demodulator circuit.
20.	The AM coaxial connector provides an output connection for the a-m demodulator circuit.

Figure 4-2. Phase Lock Tracking Filter Model PL307, Input and Output Connectors (Sheet 2 of 2)

TABLE 4-1. SUMMARY OPERATING PROCEDURE

OPERATION	CONTROL SETTINGS	SET/AGC	PLT/SIG	CAL/AGC	BANDWIDTH	COARSE FREQUENCY SET	FINE FREQUENCY SET	SWEEP TIME	SWEEP RATE	DEMODULATOR LEVEL	DEMODULATOR CUTOFF	MEMORY	REMARKS
PREOPERATIONAL CHECKOUT	MAIN PHASE (1) DETECTOR BALANCE	ACQ	SIG	EXT CAL (NO SIGNAL)	100CPS	METER LOW	12KC	MANUAL	—	—	—	IN	ADJUST MAIN PHASE DETECTOR BALANCE POTENTIOMETER UNTIL FREQUENCY METER DOES NOT DRIFT (PHASE DETECTOR ADJUSTMENT).
	FREQUENCY (1) METER ZERO	SET	SIG	EXT CAL (NO SIGNAL)	2.5CPS	METER LOW	VARY ABOUT OKC	MANUAL	—	—	—	IN	ADJUST METER ZERO POTENTIOMETER FOR ZERO FREQUENCY METER READING WHEN CORRELATION METER FLICKERS (OR ZERO BEAT IN PHONES).
	INPUT (1) MIXER BALANCE	ACQ	SIG	EXT CAL (NO SIGNAL)	2.5CPS	METER LOW	VARY ABOUT OKC	MANUAL	—	—	—	IN	IT SHOULD NOT BE POSSIBLE TO INDICATE LOCK IF INPUT MIXER IS PROPERLY BALANCED. SEE PARAGRAPH 5-48.
	CORRELATION AMPLIFIER BALANCE	SET	SIG	EXT CAL (NO SIGNAL)	ANY	ANY	ANY EXCEPT NEAR ZERO	ANY	—	—	—	—	CORRELATION METER SHOULD INDICATE ZERO. REMOVE PHASE DETECTOR ASSEMBLY AND ADJUST COR BAL POTENTIOMETER ON LOOP CONTROL ASSEMBLY UNTIL ZERO IS REACHED. (REPLACE PHASE DETECTOR).
	AUXILIARY PHASE DETECTOR BALANCE	SET	SIG	EXT CAL (NO SIGNAL)	ANY	ANY	ANY EXCEPT NEAR ZERO	ANY	—	—	—	—	CORRELATION METER SHOULD STILL INDICATE ZERO AFTER ABOVE STEP ADJUST AUXILIARY PHASE DETECTOR POTENTIOMETER FOR ZERO READING (PHASE DETECTOR ADJUSTMENT).
	AGC AMPLIFIER BALANCE	ACQ	SIG	CAL	100CPS	ANY	20KC	MANUAL	—	—	—	—	ACQUIRE 20-KC INTERNAL CALIBRATION SIGNAL. CORRELATION METER SHOULD INDICATE 100%. ADJUST AGC BAL POTENTIOMETER ON LOOP CONTROL ASSEMBLY FOR 100% READING.
SET		SET	ANY	SLOW MEDIUM, OR FAST	ANY	ANY	ANY	ANY	ANY	ANY EXCEPT CAL	ANY	ANY	TUNE SET FREQUENCY CONTROLS AS REQUIRED FOR ZERO BEAT WITH INPUT SIGNAL AS INDICATED BY CORRELATION METER OR EARPHONES.
ACQUISITION	SIGNAL, MANUAL	ACQ	SIG	SLOW MEDIUM, OR FAST	ANY	AS (2) REQUIRED	AS REQUIRED	MANUAL	ANY	ANY EXCEPT CAL	ANY	ANY	SET FREQUENCY CONTROLS MAY BE ADJUSTED AS REQUIRED TO AID SIGNAL ACQUISITION
	SIGNAL, (3) AUTOMATIC SWEEP	ACQ	SIG	SLOW MEDIUM, OR FAST	AS REQUIRED	PRESET TO VICINITY OF SIGNAL	PRESET TO VICINITY OF SIGNAL	ADJUST AS REQUIRED TO AVOID TUNING THROUGH ZERO CPS	ADJUST AS REQUIRED UP TO MAXIMUM OF BANDWIDTH SQUARED CYCLES/SEC/SEC	ANY EXCEPT CAL	ANY	IN	NOISE SPIKES MAY TRIGGER LOOP CONTROL RELAY K2, RESETTING SWEEP CENTER FREQUENCY. SWEEP RANGE THEN DRIFTS ACROSS TUNING SPECTRUM.
												OUT	ELIMINATES SWEEP DRIFT PROBLEM, BUT MAY REQUIRE MEMORY "IN" SELECTION AFTER LOCK-ON.
	PILOT, MANUAL	ACQ	PLT	SLOW MEDIUM, OR FAST	100CPS	AS (2) REQUIRED	AS REQUIRED	MANUAL	ANY	ANY EXCEPT CAL	ANY	IN	SEE DROP-LOCK, PILOT, MANUAL
												OUT	SEE DROP-LOCK, PILOT, MANUAL
	PILOT, AUTOMATIC SWEEP	ACQ	PLT	SLOW MEDIUM, OR FAST	ANY	PRESET TO VICINITY OF PILOT FREQUENCY	PRESET TO VICINITY OF PILOT FREQUENCY	ADJUST AS REQUIRED TO AVOID TUNING THROUGH ZERO CPS	ADJUST AS REQUIRED UP TO MAXIMUM OF BANDWIDTH SQUARED CYCLES/SEC/SEC	ANY EXCEPT CAL	ANY	—	—
TRACKING	PILOT	ACQ	PLT	SLOW MEDIUM, OR FAST	AS REQUIRED	—	—	—	—	—	—	—	1. ADJUST PILOT SIGNAL LEVEL TO INDICATE APPROXIMATELY 100% ON CORRELATION METER. 2. PILOT FREQUENCY MAY BE VARIED SLOWLY FOR REMOTE TUNING OF TRACKING FILTER.
	SIGNAL	ACQ	SIG	SLOW MEDIUM, OR FAST	AS REQUIRED	—	—	—	—	AS REQUIRED	AS REQUIRED	—	—
DROP LOCK	PILOT, MANUAL	ACQ	PLT	SLOW MEDIUM, OR FAST	—	—	—	MANUAL	ANY	—	—	IN	NOISE SPIKES AT SIGNAL INPUT MAY ACTIVATE SIGNAL ACQUISITION CIRCUITS, PREVENTING AUTOMATIC RETURN TO PILOT.
												OUT	NOISE SPIKES AT SIGNAL INPUT MAY ACTIVATE SIGNAL ACQUISITION CIRCUITS MOMENTARILY BUT PILOT WILL BE REACQUIRED AUTOMATICALLY.
	PILOT AUTOMATIC SWEEP	ACQ	PLT	SLOW MEDIUM, OR FAST	—	PRESET TO VICINITY OF PILOT FREQUENCY	PRESET TO VICINITY OF PILOT FREQUENCY	ANY EXCEPT MANUAL	ANY	—	—	IN	CANNOT AUTOMATICALLY REACQUIRE PILOT.
												OUT	PILOT AUTOMATICALLY REACQUIRED.
	SIGNAL, MANUAL	ACQ	SIG	SLOW MEDIUM, OR FAST	—	—	—	—	—	—	—	IN	TUNING REMAINS AT LAST KNOWN SIGNAL FREQUENCY, BUT MAY DRIFT IN EITHER DIRECTION DEPENDING ON BALANCE OF MAIN PHASE DETECTOR.
												OUT	TUNING IMMEDIATELY RETURNS TO THAT ESTABLISHED BY THE SET FREQUENCY CONTROLS.
	SIGNAL, AUTOMATIC SWEEP	ACQ	SIG	SLOW MEDIUM, OR FAST	—	—	—	—	—	—	—	IN	SWEEP BEGINS AT LAST KNOWN SIGNAL FREQUENCY AND INITIALLY MOVES UPSCALE. (4) SEE ALSO REMARKS UNDER ACQUISITION, SIGNAL, AUTOMATIC SWEEP.
												OUT	SWEEP PERFORMS AS WITH MEMORY IN BUT INITIALLY BEGINS AT FREQUENCY ESTABLISHED BY SET FREQUENCY CONTROLS.

1. ALLOW MINIMUM 15 MINUTE WARM UP TIME.
2. FOR FREQUENCIES BELOW 20KC, ROTATE COARSE FREQUENCY SET CONTROL INTO METER LOW POSITION.
3. EXCESSIVE INPUT SIGNAL STRENGTH MAY PREVENT LOCK-ON.
4. INITIAL SWEEP DIRECTION CAN BE REVERSED BY MINOR CIRCUIT MODIFICATION, SEE NOTE 5 ON OVERALL SYSTEM DIAGRAM.

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time from approximately 0.2 to 10 seconds*. In the MANUAL detent position, the control establishes the manual mode of operation. This permits the tracking filter to be manually tuned in a closed loop condition by the COARSE and FINE SET FREQUENCY controls so phase-locked acquisition of the input frequency can be effected whenever the SET/ACQ switch is switched to the ACQ position. When switched out of the MANUAL detent, the automatic sweep generator is activated and becomes functional along with the SET FREQUENCY controls.

c. SET/ACQ SWITCH. - With the SET/ACQ switch in SET condition, the SET FREQUENCY controls can be tuned manually to locate an input frequency which is indicated by a beat on the CORRELATION meter. When lock-on seems probable, phase-lock acquisition can be initiated by pressing the SET/ACQ switch to establish an ACQ (acquire) condition. If a successful lock-on is achieved, the SIG lamp glows green; if not, it remains yellow.

d. PLT/SIG SWITCH. - In tracking filters with pilot option, the PLT/SIG switch is used to establish the pilot modes of operation. To establish the pilot automatic mode, the SWEEP TIME control is rotated out of the MANUAL detent, the SET/ACQ switch is pressed to establish a SET condition, the SET FREQUENCY controls are adjusted to establish the sweep center frequency in the vicinity of the pilot frequency, and the PLT/SIG switch is pressed to establish the pilot mode (PLT lamp glows yellow). The SET/ACQ switch is pressed and the vco will sweep until the pilot signal is automatically acquired. After acquiring the pilot frequency, the PLT lamp changes from yellow to green and the SIG lamp glows yellow indicating a state of readiness for acquisition of a true signal.

The tracking filter is now tracking the pilot input frequency and will continue to do so until the true input frequency crosses the pilot frequency. The tracking filter will then drop the pilot input frequency and acquire the true input frequency. With the tracking filter locked to the true input frequency, the PLT lamp extinguishes and the SIG lamp glows green. In the case of drop-lock or signal fade, the sequence of events will depend upon the position of the MEMORY switch discussed in subparagraph e.

The procedure for signal acquisition in the pilot manual mode is essentially the same as in the pilot automatic mode. The SWEEP TIME control is, however, set in the MANUAL detent, the SET/ACQ switch is pressed to establish a SET condition, and the SET FREQUENCY controls are tuned to the exact pilot input frequency as indicated by a zero beat on the CORRELATION meter.

e. MEMORY SWITCH. - The primary purpose of the MEMORY switch is to hold the tracking filter output at the last known input frequency (memory in) in the event of drop-lock.

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*This is the "half period" or time required to sweep from one end to the other. The SWEEP TIME control should be adjusted to prevent the vco from being driven outside the tracking range (below zero and above 120 kc) in order to prevent equalizer saturation.

When operating in an automatic mode, this last known frequency serves as the center frequency about which the vco sweeps. If the memory is out when a drop-lock occurs, the vco frequency will instantly return to the tuning point established by the SET FREQUENCY controls. Memory in is characterized by the ACQ lamp glowing green, and memory out by the ACQ lamp glowing yellow. In the pilot mode, the MEMORY switch assumes an additional function. With memory in at drop-lock in the pilot mode, the tracking filter retains the last known true input frequency and can directly re-acquire the true input frequency, but it cannot reacquire the pilot. With memory out, however, the tracking filter may reacquire the pilot frequency, but it can not reacquire the true input frequency until the pilot signal has been reacquired and the true frequency re-crosses it.

Section 2. PREOPERATIONAL CHECKOUT PROCEDURE

4-3. GENERAL.

The following procedure provides preoperational calibration checks and verification of correct tracking filter operation. The procedure should be performed immediately after installation, and prior to operating the tracking filter. This procedure also will be found useful in isolating malfunctions when troubleshooting the unit. A vtvm is needed to perform steps 17 through 22. Each step in the procedure presumes the previous step has been performed.

Step 1. Press POWER switch and observe that both -15 and +15 lamps glow. Allow the filter to stabilize at the temperature it will normally experience in continuous operation.

Step 2. Press the SET/ACQ switch to establish a SET mode. Observe that the SIG lamp glows yellow. (If the PLT lamp glows yellow, press the PLT/SIG switch to extinguish it.)

Step 3. Rotate the CAL/AGC switch to EXT CAL or disconnect input signal.

Step 4. Rotate the BANDWIDTH CPS switch to 100.

Step 5. Rotate the SWEEP TIME control into the MANUAL detent.

Step 6. Rotate the FINE and COARSE SET FREQUENCY controls to their extreme counterclockwise position, and observe that the FREQUENCY meter indicates below 0 kc. Rotate both controls to their extreme clockwise position, and observe that the FREQUENCY meter indicates above 120 kc. Return SET FREQUENCY controls to 0 kc indication on meter and observe that this corresponds to a flicker of the CORRELATION meter indicating zero beat of the vco and reference oscillator signals. If necessary, adjust the meter zero until this relationship is obtained.

Step 7. Remove the phase detector assembly from its socket, and observe that the CORRELATION meter indicates zero. If it does not, adjust the CORR BAL potentiometer on the loop control assembly for exactly zero. Reinstall the phase detector assembly.

Step 8. Adjust AUX BAL potentiometer R15 at the top of the phase detector assembly until the CORRELATION meter reads exactly zero. The auxiliary phase detector is now balanced.

Step 9. Press the SET/ACQ switch to establish the ACQ mode, and rotate the SWEEP TIME control to MANUAL. Adjust MAIN BAL potentiometer R3 at the top of the phase detector until the FREQUENCY meter shows no drift either up-scale or down-scale. The main phase detector is now balanced. Press the SET/ACQ switch to reestablish the SET mode.

NOTE

With the COARSE SET FREQUENCY control in METER LOW position, cycle the FINE SET FREQUENCY control between zero and 24 kc several times to minimize the hysteresis effects in the controllable inductor.

Step 10. Rotate the COARSE SET FREQUENCY control fully counterclockwise to the METER LOW switch position. Rotate the FINE SET FREQUENCY control to verify that the FREQUENCY meter changes approximately 24 kc over the ten turns of the control.

Step 11. Rotate the CAL/AGC switch to CAL. This will apply an internal 20-kc signal to the input for calibration and checkout.

Step 12. Rotate the AM and PM LEVEL controls fully clockwise.

Step 13. Adjust the FINE SET FREQUENCY control to obtain an indication of approximately 20 kc on the lower scale of the FREQUENCY meter.

Step 14. Slowly rotate the FINE SET FREQUENCY control clockwise while observing the CORRELATION meter. When the meter pointer indicates a low-frequency beat (by moving slowly up and down the scale), press the SET/ACQ switch to acquire the 20-kc calibrating signal. Observe that the meter now indicates approximately 100 percent correlation and the SIG lamp glows green. Adjust AGC BAL potentiometer R2 on the top of the loop control module so the CORRELATION meter reads exactly 100 percent. The agc amplifier is now balanced.

Step 15. Verify a FREQUENCY meter indication of 20 kc. If the meter indication is incorrect, adjust the METER ZERO screwdriver control until a 20-kc indication is obtained. Return to the SET mode by pressing the SET/ACQ switch, and repeat step 6 to ensure proper zero setting.

Step 16. Rotate the COARSE SET FREQUENCY control out of the METER LOW position and acquire the 60-kc (3rd harmonic) calibrate signal as in step 14.

Step 17. Connect a vtvm to the ANAL coaxial connector at the rear of the chassis. On the analog frequency amplifier (module X13), adjust BAL potentiometer R3 (figure 5-1) to zero volts with the vtvm sensitivity at least 3 volts full scale. The analog frequency amplifier is now balanced.

Step 18. Press the SET/ACQ switch to establish a SET mode.

Step 19. Return the CAL/AGC switch to the FAST position.

Step 20. Connect the vtvm to the AM coaxial connector at the rear of the chassis.

Step 21. On the demodulator assembly (module X9), adjust AM BAL potentiometer R27 (figure 5-1) for zero volts on the vtvm.

Step 22. Move the vtvm to the PM coaxial connector. On the demodulator module, adjust PM BAL potentiometer R5 for zero volts on the vtvm. The demodulator amplifiers are now balanced. Remove the vtvm.

Step 23. Rotate the SWEEP TIME and SWEEP RATE controls fully clockwise.

Step 24. With the COARSE SET FREQUENCY control adjusted to read 60 kc on the FREQUENCY meter, press the SET/ACQ switch to establish the ACQ mode. Observe that the FREQUENCY meter sweeps between 10 kc and 110 kc.

Step 25. Rotate the CAL/AGC switch to CAL position, and observe that the filter automatically acquires the nearest 20-kc harmonic. (Allow at least 10 seconds for the calibration signal to reach full strength.) Press the SET/ACQ switch to establish the SET mode.

Step 26. Press the PLT/SIG switch to establish the pilot mode. Adjust PLT COR BAL potentiometer on the top of the pilot module for zero indication on the CORRELATION meter. Return the PLT/SIG switch to SIG mode.

Section 3. OPERATING PROCEDURE

4-4. GENERAL.

This section contains specific tracking filter operating instructions. These instructions include preliminary adjustments of the tracking filter, procedures for the selection of internal or external reference frequency, and signal acquisition procedures.

4-5. PRELIMINARY ADJUSTMENTS.

Prior to setting up the tracking filter to track an input frequency, perform the preoperational checkout procedure in section 2 of this chapter.

Step 1. Connect the signal to be tracked to the SIG IN connector at the rear of the chassis, and adjust its signal-plus-noise amplitude to approximately 1 volt rms. Connect the equipment using the output to the desired SIG OUT connector (X1, X10, or X100).

Step 2. Rotate the BANDWIDTH CPS switch to the bandwidth desired.

Step 3. Rotate the CAL/AGC switch to FAST.

Step 4. Set the MEMORY switch to indicate the condition desired.

Step 5. Press the POWER switch. Observe that +15 and -15 lamps glow red, and SIG lamp glows yellow. Allow several minutes for the circuits to stabilize.

Step 6. Press the SET/ACQ switch to establish a SET mode. Observe that the SET lamp glows red and the SIG lamp glows yellow.

4-6. REFERENCE FREQUENCY SELECTION.

The tracking filter is normally operated with an internally generated 25-mc reference frequency. This basic reference signal, which is obtained from Reference Oscillator Assembly 9468000 (module X10), is applied to the phase detector and the voltage controlled oscillator through a frequency divider assembly (module X11). When parallel and synchronous operation of more than one tracking filter is desired, a single external reference frequency can be applied to all units. The internal oscillator is disabled, and its output is replaced by the external signal. This substitution is accomplished as follows:

Step 1. Connect an oscilloscope to the REF OSC connector at the rear of the tracking filter chassis. The signal displayed is the 250-kc reference actually applied to the main and auxiliary phase detectors. Observe and record the amplitude of this signal.

Step 2. Remove Reference Oscillator Assembly 9468000 from its socket (X10).

Step 3. Connect a jumper between pins 1 and 3 on socket X10. This jumper can be a plug-in jumper at the top of the socket for temporary operation, or a soldered connection at the socket pins under the chassis for permanent operation.

Step 3. Connect the external 25-mc reference signal to the EXT REF connector at the rear of the chassis. This signal must have a source impedance of 50 ohms and it's level must be adjustable.

Step 5. The level of the applied 25-mc reference signal should next be increased until a sinusoidal waveform again appears on the oscilloscope. The amplitude of this signal should be adjusted to correspond with the value obtained in step 1 of this procedure. The value of fixed resistor R22 (located between pins 1 and 7 of socket X11) can be adjusted as required to obtain the desired oscilloscope presentation. In no case should the waveform amplitude exceed 10 percent of the level in step 1.

4-7. MANUAL MODE SIGNAL ACQUISITION.

This procedure presumes that the setup procedure in paragraph 4-5 has been performed.

Step 1. Rotate the SWEEP TIME control into the MANUAL detent.

Step 2. Rotate the COARSE SET FREQUENCY control to approximately the input frequency as indicated on the FREQUENCY meter.

Step 3. Press the SET/ACQ switch to establish the ACQ condition.

Step 4. Rotate the FINE SET FREQUENCY control through its range until a zero beat is indicated on the CORRELATION meter and/or is heard over phones connected at the PHONES jack.

Step 5. When near zero beat condition, as indicated by a slowly varying CORRELATION meter reading, the filter will lock-on unless the SET FREQUENCY controls are rotated too quickly or the signal is too weak. At signal lock-on, the CORRELATION meter indicates approximately 100, the ACQ lamp glows green or yellow depending on whether the MEMORY switch is set to IN or OUT, and the SIG lamp glows green.

Step 6. In the event of drop-lock as indicated by the SIG lamp changing from green to yellow and the CORRELATION meter reading zero, manually tune the SET FREQUENCY controls to reacquire the signal by performing steps 4 and 5.

4-8. AUTOMATIC MODE SIGNAL ACQUISITION.

This procedure presumes that the setup procedure in paragraph 4-5 has been performed.

Step 1. Rotate the SWEEP TIME control out of the MANUAL detent.

Step 2. Rotate the SET FREQUENCY controls to approximately the input frequency, as indicated on the FREQUENCY meter, to establish the sweep center frequency.

Step 3. Press the SET/ACQ switch to establish an ACQ condition. The ACQ lamp glows green or yellow, depending on whether the MEMORY switch is IN or OUT and the SIG lamp glows yellow. Rotate the SWEEP TIME control to adjust the sweep time as desired from 0.2 to 10 seconds. (Adjust the SWEEP TIME control to prevent sweeping outside of the normal 120-kc range.)

Step 4. Adjust the SWEEP RATE control as desired. Maximum sweep rate is approximately "dial bandwidth" squared cycles per second per second. (For example, with a 10-cps tracking loop bandwidth, the maximum sweep rate would be 100 cycles/sec/sec.) The SWEEP RATE control will reduce the sweep rate to as much as $B^2/10$.

Step 5. With the SWEEP TIME and SWEEP RATE controls correctly adjusted signal lock-on will be accomplished automatically and will be noted by the CORRELATION meter indicating approximately 100 and the SIG lamp changing from yellow to green.

Step 6. In the event of drop-lock as indicated by the SIG lamp changing from green to yellow and the CORRELATION meter indicating zero, signal acquisition will occur automatically if the input frequency reappears within the sweep range. If the input frequency reappears at a frequency beyond the sweep and loop pull-in range, slight readjustment of the FINE SET FREQUENCY control may be necessary.

4-9. PILOT MODE SIGNAL ACQUISITION.

a. MANUAL. - This procedure presumes that the setup procedure in paragraph 4-5 has been performed.

Step 1. Rotate the SWEEP TIME control into the MANUAL detent.

Step 2. Press the PLT/SIG switch to establish the pilot (PLT) mode. Observe that the PLT lamp glows yellow.

Step 3. Rotate the COARSE SET FREQUENCY control to the pilot frequency as indicated on the FREQUENCY meter.

Step 4. Rotate the FINE SET FREQUENCY control through its range until a beat is indicated on the CORRELATION meter.

Step 5. When near zero beat condition, as indicated by a slowly varying CORRELATION meter reading, press the SET/ACQ switch to acquire the pilot frequency lock-on, the CORRELATION meter indicates the output of the pilot correlation amplifier, the PLT lamp glows green, the SIG lamp glows yellow, and the ACQ lamp glows green or yellow depending on whether the MEMORY switch is IN or OUT. From this point true input frequency lock-on will be accomplished automatically. True input frequency lock-on is characterized by the PLT lamp extinguishing and the SIG lamp glowing green.

NOTE

The input pilot signal level may be adjusted to read 100 percent on the CORRELATION meter. This may be accomplished by adjusting the pilot signal source or by adjusting the PLT LEVEL control on the pilot module. (See figure 5-1.)

Step 6. Set the MEMORY switch to the desired position. Note with the MEMORY switch set to IN position, the tracking filter can directly reacquire the true input frequency in the event of drop-lock. With the MEMORY switch set to OUT position, the tracking filter can only reacquire the pilot frequency. If the true input frequency does not appear at the pilot frequency, the tracking filter can

not reacquire the true input frequency in this mode; however, in the case of poor signal-to-noise conditions, this mode may prove advantageous because it will tend to reject false lock indications caused by noise spikes.

Step 7. In the event of drop-lock as indicated by the SIG lamp changing from green to yellow and the CORRELATION meter indicating zero, the method used to reacquire the true input frequency will depend on whether the memory circuit was in or out at the instant of drop-lock.

Step 8. If the memory circuit was in, signal acquisition will occur automatically if the true input frequency reappears within the loop pull-in range. Otherwise, slight readjustment of the FINE SET FREQUENCY control may be necessary.

Step 9. If the memory circuit was out, press the PLT/SIG switch to disengage the pilot circuit. Reacquire the true input frequency by performing steps 4 and 5 of paragraph 4-7.

b. AUTOMATIC. - This procedure presumes that the setup procedure in paragraph 4-5 has been performed.

Step 1. Rotate the SWEEP TIME control out of the MANUAL detent.

Step 2. Press the PLT/SIG switch to establish the pilot mode. Observe that the PLT lamp glows yellow.

Step 3. To establish the sweep center frequency near the pilot frequency, rotate the SET FREQUENCY controls to the vicinity of the pilot frequency.

Step 4. Press the SET/ACQ switch to establish an ACQ condition. At pilot frequency lock-on the CORRELATION meter indicates the output of the pilot correlation amplifier, the PLT lamp glows green, the SIG lamp glows yellow, and the ACQ lamp glows green or yellow depending on whether the MEMORY switch is at the IN or OUT position. From this point true input frequency lock-on will be accomplished automatically. True input frequency lock-on is characterized by the PLT lamp extinguishing and the SIG lamp glowing green.

Step 5. Set the MEMORY switch to the desired position. Note with the MEMORY switch set to IN position, the tracking filter can directly reacquire the true input frequency in the event of drop-lock. With the MEMORY switch set to OUT position, the tracking filter can only reacquire the pilot frequency and can not reacquire the true input frequency; however, in the case of poor signal to noise conditions, this mode may prove advantageous because it will tend to reject false lock indications caused by noise spikes.

Step 6. In the event of drop-lock as indicated by the SIG lamp changing from green to yellow and the CORRELATION meter indicating zero, the method used to reacquire the true input frequency will depend on whether the memory circuit was in or out at the instant of drop-lock.

Step 7. If the memory circuit was in, signal acquisition will occur automatically if the true input frequency reappears within the sweep range. If the true frequency reappears at a frequency beyond the sweep range, slight readjustment of the FINE SET FREQUENCY control may be necessary.

Step 8. If the memory circuit was out, press the PLT/SIG switch to disengage the pilot circuit. Signal acquisition will now occur automatically as discussed in step 7.

NOTES

Chapter 5

MAINTENANCE

This chapter presents the information required to maintain operation of the tracking filter. The information in section 1 is presented in two categories: routine maintenance and corrective maintenance. Routine maintenance encompasses the periodic cleaning and visual inspection necessary to detect physical defects. Corrective maintenance involves performance checks and associated adjustments, and trouble isolation procedures. Corrective maintenance should be attempted only by experienced technical personnel who have made a careful study of the functional analysis and the maintenance procedures.

Section 2 gives a procedure for verifying that the tracking filter meets the technical specifications listed in table 1-6.

Section 1. TROUBLESHOOTING

5-1. TEST EQUIPMENT REQUIRED.

The test equipment required to maintain the tracking filter is listed in table 5-1.

5-2. ROUTINE MAINTENANCE.

Routine maintenance is work performed on equipment, usually when the equipment is not in use, to keep it in good working order so breakdowns and needless interruptions in service will be kept to a minimum.

a. CLEANING. - Proper cleaning of the equipment will aid in minimizing breakdowns or malfunctions. Prevailing military standard requirements for cleaning,or the following cleaning methods may be used, as applicable.

(1) A clean, dry, lint-free cloth, a dry brush, or a vacuum cleaner may be used to remove loose dust, dirt, and lint.

(2) If available, dry compressed air at a line pressure not exceeding 30 psi may be used to remove dust from inaccessible places, providing that care is exercised to prevent transfer of dirt to nearby parts. Care must also be exercised to ensure that damage to components does not result from the air blast.

TABLE 5-1. TEST EQUIPMENT REQUIRED

Equipment	Type
Frequency Counter	Beckman 7170
Signal Generator	Hewlett-Packard 200CD
RMS Voltmeter	Hewlett-Packard 400D
Noise Generator	General Radio 1390A
Function Generator	Hewlett-Packard 202A
Audio Amplifier	Hewlett-Packard 450A
VTVM	Hewlett-Packard 410B
Oscilloscope	Hewlett-Packard 130B, or Tektronix 581 with Type CA plug-in and adapter. (For Lissajou's pattern observations).
	Tektronix 581 with Type 80 plug-in. (For high-frequency measurements.)

(3) Corrosion should be removed with fine crocus cloth (No. 000). Emery paper or steel wool must never be used to clean near electrical equipment; the particles which come from such materials are conductive and can create short circuits. All dust and metallic particles should be removed by compressed air or vacuum cleaning. If compressed air is used, prevent the scattering of particles to magnetic parts.

(4) Pure ethyl alcohol may be used to clean contact points and to remove excess rosin flux; it must not be used, however, to clean insulating varnish.

b. VISUAL INSPECTION. - Prior to performing corrective maintenance procedures, a brief visual inspection may quickly reveal the cause of equipment malfunction. Visual inspection should include the following:

(1) Check for defective fuses.

(2) Ensure that plug-in elements are securely fastened in place and that their connectors are properly mated. Do not tamper with maintenance controls on plug-in elements.

(3) Check transistors and diodes for damaged leads, and loose connections at sockets.

(4) Check for damaged or loose connectors, broken wires, and frayed or cracked insulation.

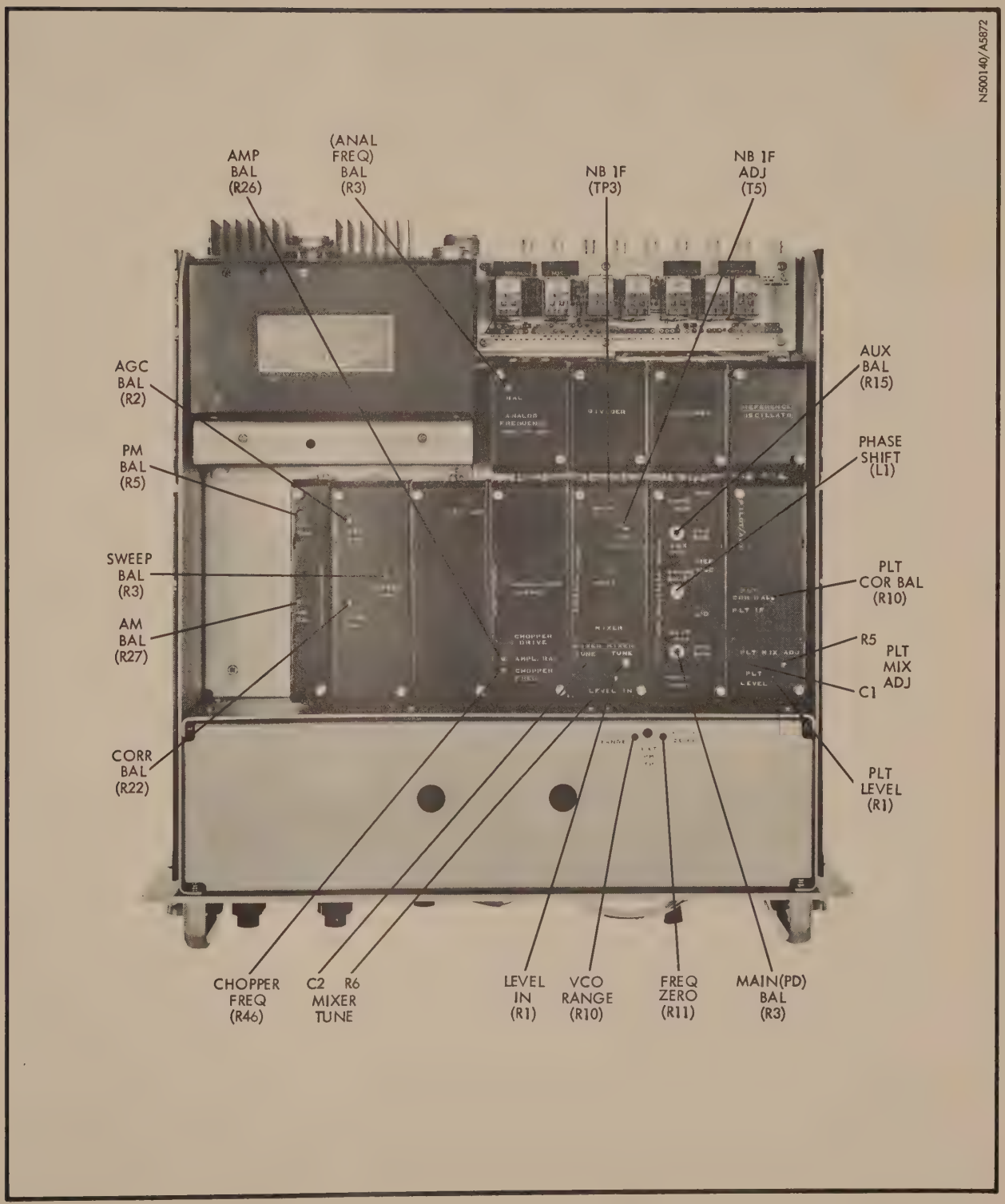


Figure 5-1. Phase Lock Tracking Filter Model PL307, Adjustments Identification

5-3. CORRECTIVE MAINTENANCE.

Most troubles can be isolated to a faulty subassembly, plug-in circuit, or other parts by carefully performing the detailed checkout procedures in paragraph 5-4 and analyzing the responses of the readout devices. Several other troubleshooting aids are provided in this paragraph. Table 5-2 permits correlation of indicator displays with control relay logic under all conditions of operation. Table 5-3 lists voltage measurements taken at easily accessible points throughout the unit. A list of possible malfunctions that may be encountered in normal operation, together with suggested corrective action, is given in table 5-4. The corrective action for each malfunction is correlated with the appropriate checkout procedure in paragraph 5-4. Figure 5-1 illustrates the maintenance adjustment points called out in the checkout procedure.

a. INDICATOR AND RELAY STATUS. - Table 5-2 correlates indicator displays and relay status for all conditions encountered during a normal operating sequence. The use of this table will, in many cases, localize a malfunction to a particular relay, or to the circuits driving the relay. The use of transparent dust covers permits visual determination of relay status.

b. TYPICAL VOLTAGE MEASUREMENTS. - Table 5-3 is a listing of typical d-c voltage measurements made at the pins of the tracking filter circuit card and plug-in module sockets. No significant measurements are available at the bandswitch card (socket X2), and the only significant measurements at modules X10 through X12 are -15 volts at pin 4, and +15 volts at pin 6. The indicated measurements were obtained using a high-impedance vtvm connected between each pin and chassis ground, and under the following front panel control conditions:

(1) SET/ACQ switch in SET mode.

(2) PLT/SIG switch in SIG mode.

(3) SWEEP TIME control in MANUAL detent.

(4) CAL/AGC switch in FAST position.

(5) Demodulator LEVEL controls fully clockwise.

(6) SET FREQUENCY controls adjusted for 60 kc on FREQUENCY meter.

(7) No input signal at SIG IN connector.

c. TROUBLESHOOTING. - A list of possible malfunctions that may be encountered in normal use of the equipment is given in table 5-4. The corrective action for each malfunction is correlated with the appropriate procedure in paragraph 5-4. It should be realized that this list cannot anticipate all possible malfunctions, and is therefore limited to those most likely to occur. Should any difficulty be experienced in restoring the tracking filter to normal operation, the user is invited to contact engineering personnel at Interstate Electronics Corporation for further information.

TABLE 5-2. INDICATOR DISPLAYS AND RELAY STATUS

Condition	SET	*ACQ	SIG	PLT	K1	K2	K3	K4	K5	K6	K7
Without Pilot:											
Set	Red	-	yellow	-	-	-	-	-	-	-	-
Acquire											
Automatic	-	grn/yel	yellow	-	X	-	-	X	-	-	-
Manual	-	grn/yel	yellow	-	X	-	X	-	-	-	-
Lock-on	-	grn/yel	green	-	X	X	X	-	X	-	-
Drop-Lock**											
Automatic	-	grn/yel	yellow	-	X	-	-	X	-	-	-
Manual	-	grn/yel	yellow	-	X	-	X	-	-	-	-
With Pilot:											
Set	Red	-	yellow	-	-	-	-	-	-	-	-
Pilot acquire											
Automatic	-	grn/yel	-	yellow	X	-	-	X	-	X	-
Manual	-	grn/yel	-	yellow	X	-	-	-	-	X	-
Pilot Lock-on	-	grn/yel	yellow	green	X	-	-	-	-	-	X
Signal Lock-on	-	grn/yel	green	-	X	X	X	-	X	-	-
Drop-Lock											
Automatic											
memory in	-	green	yellow	-	X	-	-	X	X	-	-
memory out	-	yellow	-	yellow	X	-	-	X	-	X	-
Manual**	-	yellow	-	yellow	X	-	X	-	-	-	-

*ACQ lamp glows green with memory in and glows yellow with memory out.

**Memory out; with memory in, K5 remains energized. PLT lamp is off, SIG lamp is yellow.

TABLE 5-3. TYPICAL D-C VOLTAGE MEASUREMENTS

Pin No.	X1 9474000	X3 9467000	X4 9461000	X5 9460000	X6 9462000	X7 9463000	X8 9464000	X9 9465000	X13 9469000
1							-5.0	±0.1	-0.1
2		-2.2	+0.5			+9.0		-0.6	
3		-15.0	+0.5	+0.5				-1.0	
5				+0.5			-15.0		
6				-6.5				-1.0	+15.0
7		+15.0	+15.0	+15.0	+15.0	+15.0	+15.0	+15.0	
8	-2.0	-2.0					-0.2		-2.0
9	-5.2								
10	-6.2		-7.5	+15.0			-15.0		
11	-7.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	
12	-7.2						-0.2		
13			+0.5				-0.2	-1.0	
14				-0.24					
16	-14.0		+0.5	-0.24		-7.5	-0.2	-1.0	
17								±0.1	
18	+7.2							-0.6	
23	-15.0								
25	-13.0								
30	-15.0								
31	-0.1								
33	-14.0								
34	-14.0								
40	+15.0								
41	+14.0								

TABLE 5-4. TROUBLESHOOTING DATA

Trouble	Cause and Corrective Action
CORRELATION meter does not read zero with no input to unit, and SET/ ACQ switch is in SET position.	AUX BAL and CORR BAL potentiometers require rebalancing (paragraph 4-3, steps 7 and 8, or paragraph 5-4b, step 12).
Many spurious signal beats on CORRELATION meter and phones. Generally less sensitive than normal.	Excessive input signal strength. Reduce input level at source or by adjusting INPUT LEVEL ADJ potentiometer R1 on the input mixer/i-f module. RMS input signal-plus-noise voltage should not exceed 1 volt measured at the SIG IN connector.
CORRELATION meter continuously indicates more than 100% correlation while tracking strong, clean signal.	AGC amplifier unbalanced. Adjust AGC BAL potentiometer until CORRELATION meter reads 100% (paragraph 5-4b, step 14).
CORRELATION meter continuously reads less than 100% on the wider bands, but reducing bandwidth brings indication up to 100%.	Insufficient input signal strength. Adjust INPUT LEVEL ADJ potentiometer R1 on the input mixer/i-f module until there is more than enough signal to cause 100% CORRELATION meter reading on all bands.
SET FREQUENCY controls either do not cover the full range of the FREQUENCY meter, or they overdrive the meter with SET/ACQ switch in SET mode.	At vco driver (card X1) replace fixed resistor R3 with smaller value in case of insufficient meter drive. For excessive drive, replace with increased resistance value. Reset METER ZERO potentiometer (paragraph 5-4b, steps 1 through 5).
Rapid drift, in either direction, of FREQUENCY meter in 100-cps bandwidth and MANUAL mode operation.	Main phase detector requires balancing (paragraph 5-4b, step 11, or paragraph 4-3, step 9).

Table 5-4. Troubleshooting Data (Continued)

Trouble	Cause and Corrective Action
FREQUENCY meter inaccurate or appears to drift.	This can be due to an improper adjustment of the vco range, or it can be a natural effect of the vco variable inductor's inherent hysteresis. Inductor hysteresis can cause as much as ±5% error in meter readings. With proper adjustment of the vco zero potentiometer and the METER ZERO control, the accuracy of meter readings in the lower frequency range can be increased considerably, increasing its value as an aid to low-frequency acquisition.
SIG indicator glows green but signal lock-on does not actually occur (2.5-or 5-cps bandwidth operation).	This can be due to excessive signal strength. Effect can be pronounced with 20-kc internal CAL signal because of strong fundamental. To correct, reduce input signal, or acquire on wider bandwidth, narrowing after acquisition.
SIG indicator glows green continuously in presence of noise input without signal.	This is normal operation. An input noise level of approximately 1 volt rms is adequate to trigger the loop control circuits irrespective of input signal level.
Filter acquires and locks on zero frequency.	Input mixer unbalanced. Adjust the MIXER TUNE control on input mixer/i-f module (paragraph 5-4b, steps 6, 7, 8 and 9).
Extreme difficulty in acquiring or holding lock (2.5-or 5-cps bandwidth operation).	Equalizer unbalanced and/or CHOPPER FREQ not properly adjusted (paragraph 5-4b, steps 11 through 19).
Excessive transients when switching bandwidths.	Rebalance SWEEP BAL potentiometer and/or readjust CHOPPER FREQ potentiometer while switching bandwidths until minimum transients are obtained (paragraph 5-4b, steps 11-15 and 19).

Table 5-4. Troubleshooting Data (Continued)

Trouble	Cause and Corrective Action
Signal cannot be acquired, and no x1 output signal available.	(a) No 250-kc reference signal available to drive phase detectors and output mixer. Check for presence of x10 and x100 output signals to determine point of failure in reference oscillator-divider chain. (b) No x1 vco signal (250 kc to 370 kc). Perform same check as in (a) above to determine point of failure.
Difficulty in acquiring signal. Filter seems to reject signal just at verge of acquisition.	Input signal level excessive, or auxiliary phase detector misadjusted. Reduce input signal level, or adjust INPUT LEVEL ADJ control on input mixer/i-f amplifier module. Adjust AUX BAL (paragraph 4-3, steps 7 and 8). At frequencies lower than 1 kc, an unbalanced input mixer can cause similar symptoms. See paragraph 5-4b, steps 6 and 7.
In automatic sweep, the filter appears to acquire a static frequency more easily when moving upscale than downscale (or vice-versa).	Equalizer unbalanced (paragraph 5-4b, steps 11 through 19), or main phase detector unbalanced (paragraph 4-3, step 9).
Tracking performance different for positive and negative acceleration signals.	Rebalance main phase detector (paragraph 4-3, step 9, or paragraph 5-4b, step 11).
Either +15 or -15 power supply lamps on power switch do not glow, but filter operates normally.	(a) Lamp burned out or loose; remove, examine, and replace lamp with special tool provided with filter.

The loop control assembly (module X8) is not essential to basic tracking loop operation. This can be used as an aid in the isolation of a fault to the tracking loop or the loop control circuits. The loop may be locked with the loop control module removed from its socket by selecting the MANUAL mode with the SWEEP TIME control and proceeding with a normal manual mode acquisition. The CORRELATION meter and the green SIG lamp are both rendered inoperative by removing the loop control module, but the headphones may be used as an acquisition aid and lock-on indicator. Also, the oscilloscope presentation of the phase detectors outlined in paragraph 5-4b, steps 11 through 14, provides an excellent acquisition aid and lock-on indicator. This x-y oscilloscope presentation is used at the factory as a primary indicator of loop operation.

5-4. DETAILED CHECKOUT PROCEDURE.

Each step in this procedure presumes the previous step has been performed satisfactorily.

a. PRELIMINARY SETTINGS.

Step 1. Press the POWER switch and observe that both the -15 and +15 lamps glow red.

Step 2. Press the SET/ACQ switch to establish a SET condition. Observe that the SET lamp glows red.

Step 3. Rotate the CAL/AGC switch to FAST position, set BANDWIDTH CPS switch to 100 cps.

Step 4. Rotate the SWEEP TIME control into MANUAL detent. Connect a vtvm between ground and the +15-volt buss. Adjust the + potentiometer on the +15-volt power supply for +15 volts.

Step 5. Repeat step 4 for the -15-volt power supply.

b. ADJUSTMENTS.

Step 1. Connect a counter to the VCO coaxial connector at the rear of the chassis.

Step 2. Adjust the COARSE and FINE SET FREQUENCY controls to their extreme counterclockwise position and adjust FREQ ZERO potentiometer R11 (figure 5-1) until counter reads 248 kc. Ensure that the COARSE SET FREQUENCY control is in METER LOW detent position.

Step 3. Rotate the FINE SET FREQUENCY control until counter reads 250 kc, and adjust METER ZERO control until FREQUENCY meter reads zero.

Step 4. Rotate the COARSE and FINE SET FREQUENCY controls fully clockwise, and adjust VCO RANGE potentiometer R10 fully clockwise. Adjust FREQ ZERO potentiometer R11 for exactly 371 kc on the counter.

Step 5. It may be necessary to repeat steps 2, 3, and 4 in sequence several times until no further adjustment is required. The vco is now fully adjusted.

CAUTION

Be sure to switch the oscilloscope for an a-c input. Do not accidentially short or ground the NB IF test point because doing so will damage the circuit components.

Step 6. On the input mixer/i-f amplifier, connect a high-impedance probe from an oscilloscope to the NB IF test point. With no signal at the SIG IN connector, adjust the SET FREQUENCY control until the counter reads 250 kc.

Step 7. Remove the phase detector assembly, (module X4) and rotate BANDWIDTH CPS to 2.5 cps. On the input mixer/i-f amplifier, adjust MIXER TUNE (R6) and then MIXER TUNE (C2) for minimum 250-kc presentation on the oscilloscope. Repeat this procedure alternating between R6 and C2 until no further improvement is noted. The peak-to-peak 250-kc signal voltage at the NB IF test point should not exceed 150 millivolts.

Step 8. Rotate the CAL/AGC switch to CAL position. Adjust the SET FREQUENCY controls for exactly 270 kc on the counter. Rotate BANDWIDTH CPS switch to 100 cps.

Step 9. At the input mixer/i-f amplifier, adjust NB IF ADJ transformer T5 (figure 5-1) for maximum 250-kc presentation on the oscilloscope. This completes the input mixer/i-f amplifier alignment.

Step 10. Return the CAL/AGC switch to FAST position, and reinsert the phase detector assembly.

Step 11. Connect the vertical amplifier of the oscilloscope (d-c input) to the coaxial connector labeled MPD (main phase detector monitor) on the rear of the chassis. At the phase detector/reference oscillator assembly, adjust the MPD BAL potentiometer (figure 5-1) for zero volts on the oscilloscope using a high sensitivity scale (at least 50 mv/cm.)

Step 12. Connect the horizontal amplifier of the oscilloscope to the coaxial connector labeled APD (auxiliary phase detector monitor). At the phase detector/reference oscillator, adjust the APD BAL potentiometer (figure 5-1) for zero volts. With correct adjustment of the MPD BAL and APD BAL potentiometers, the oscilloscope presentation is a dot in the center of the screen. Now adjust CORR BAL potentiometer for zero indication on the CORRELATION meter.

Step 13. Rotate the CAL/AGC switch to CAL position. Rotate the COARSE SET FREQUENCY control to approximately 20 kc on the FREQUENCY meter, and adjust the FINE SET FREQUENCY control for a zero beat presentation on the oscilloscope.

NOTE

An approaching zero beat is indicated by a circle increasing in size until the dot ceases to move at zero beat. If the oscilloscope presentation is not a circle, adjust PHASE SHIFT coil L1 on the phase detector/reference oscillator module. Unequal loads on the APD and MPD test points will distort the oscilloscope presentation. Therefore, ensure that both test points are equally loaded before adjusting PHASE SHIFT coil L1. Refer to paragraph 2-12b for a discussion of the 250-kc reference frequency driving coil L1.

Step 14. Press the SET/ACQ switch to acquire signal lock-on. Observe that the ACQ lamp glows green and the CORRELATION meter indicates approximately 100-percent correlation. Adjust the AGC BAL potentiometer on the loop control module for exactly 100 on the CORRELATION meter. The oscilloscope presentation will now be a dot on the right side of the screen corresponding to +0.5-volt output for the auxiliary phase detector. The APD and MPD test points present a 500,000-ohm output impedance; therefore, the oscilloscope presentation will be affected unless the oscilloscope input impedance is greater than 10 megohms.

NOTE

The oscilloscope techniques and presentation discussed in steps 11 through 14 are the most effective signal acquisition aids and maintenance aids yet devised. These techniques are used at the factory almost to exclusion of all others in order to observe the basic performance of the filter. Vertical deviations of the spot discussed in step 14 represent transient phase errors in the loop, although exact measurements of angular phase excursions should be attempted. Use of this presentation as an acquisition aid is recommended in all tracking filter installations.

Step 15. With the SWEEP RATE control fully clockwise, adjust the SWEEP BAL potentiometer on the loop control assembly to minimize the phase transient observed on the oscilloscope connected as in steps 10 and 11 while switching between the 50- and 100-cps bands with the BANDWIDTH CPS switch. Repeat this adjustment several times while moving the SWEEP TIME control clockwise about a quarter-turn between adjustments, until the control is fully clockwise. Rotate the SWEEP TIME control into the MANUAL detent.

Step 16. Press SET/ACQ switch to establish SET condition.

Step 17. On a very sensitive vtvm range (100 mv full scale or better), connect the probe to the EQUALIZER OUTPUT test point on the equalizer module. Adjust AMPL BAL potentiometer (figure 5-1) for zero volt on the vtvm.

NOTE

If a sensitive oscilloscope (10 mv/cm or better) is used for this measurement, a direct probe may be used.

Step 18. Repeat step 14.

Step 19 With the oscilloscope connected as in steps 10 and 11, slowly switch the BANDWIDTH CPS switch from 100 cps to lower bandwidths until a phase transient is noticed by movement of the dot as the bandwidth is changed. At the highest bandwidth where this is noticed, switch back and forth between adjacent bandwidths and at the same time slowly adjust the CHOPPER FREQ potentiometer on the equalizer module (figure 5-1) to minimize the transient. When the transient is minimized, switch to a lower bandwidth and repeat the procedure. Continue this procedure until it is possible to switch to 2. 5 cps with a minimum of transients.

Step 20. Connect the oscilloscope (Hewlett-Packard 130B, or equivalent) and the counter to the VCO OUT coaxial connector on the rear of the chassis. Observe that the waveform displayed on the oscilloscope changes frequency smoothly between 250 kc and 370 kc. If the frequency exhibits sudden jumps or high noise levels near the ends of the range, refer to the divider alignment procedure in paragraph 5-5. If the frequency exhibited is normal, the tracking filter is ready for operation. Remove all test equipment.

5-5. DIVIDER ALIGNMENT PROCEDURE.

As explained in step 20 of the detailed checkout procedure, this procedure is not to be performed unless the sine-wave output at the VCO OUT connector is incorrect. All waveform and voltage measurements mentioned in this procedure must be made with an oscilloscope (Tektronix 581 with type 80 vertical plug-in unit, or equivalent).

CAUTION

When making measurements at points on the circuit boards, components may be damaged if the test probe is allowed to make contact with more than one conductor at a time.

Step 1. Remove the loop control assembly (module X8), the demodulator assembly (module X9), and the exposed vco assembly side cover. *Do not use a module extender in this procedure.* Monitor the collector signal of transistor Q2 in the vco assembly with the Tektronix 581 oscilloscope. Adjust T1 to set up the frequency response curve shown in figure 5-2.

Replace the vco assembly side cover, the loop control assembly, and the demodulator.

Step 2. Remove the reference oscillator assembly (module X10), the reference divider assembly (module X11), the vco divider assembly (module X12), and the analog frequency amplifier (module X13). Remove the side covers of the reference divider module and insert it into the vco divider socket (X12). *Do not use a module extender for this procedure.*

Step 3. Monitor the signal at test point TP2 with the Tektronix 581 oscilloscope (table 5-5 waveforms 1, 2, and 3), and adjust potentiometer R21 (located under the chassis on socket X12) and L1 (located in the divider assembly) to obtain the frequency response shown in figure 5-3.

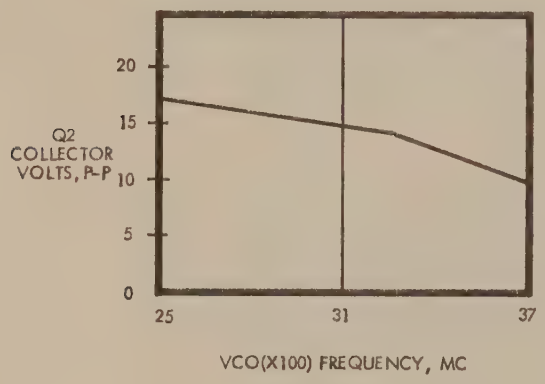


Figure 5-2. Frequency Response at Q2 Collector

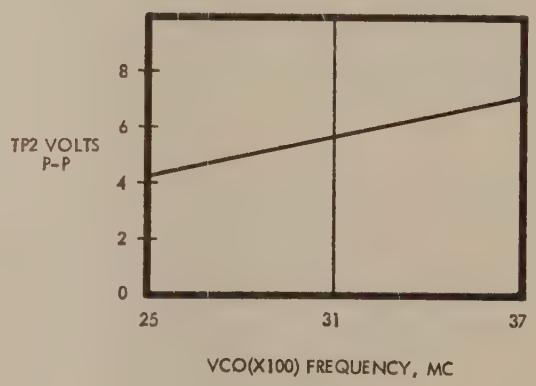


Figure 5-3. TP2 Frequency Response

Step 4. Observe the waveform at test point TP3 while changing the vco frequency, and ensure that jitter free divide-by-five action takes place throughout the vco range (4.8 mc to 7.6 mc at TP3). Small readjustments of L1 and R21 may be required to maximize the bandwidth of the divide-by-five circuit. The waveforms observed at TP3 are waveforms 4, 5, and 6 shown in table 5-5.

Step 5. Observe the waveform at test point TP6 (table 5-5, waveform 9), and adjust potentiometer R8 for maximum divider bandwidth (approximately 490 kc to 750 kc).

Step 6. Remove the reference divider module from the vco divider socket (X12) and measure the value of potentiometer R21. Install a fixed composition resistor R22 of the nearest standard value between pins 7 and 1 on the reference divider socket (X11).

TABLE 5-5. FREQUENCY DIVIDER SIGNAL TRACING CHART

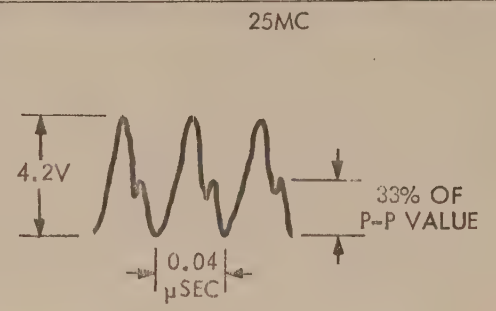
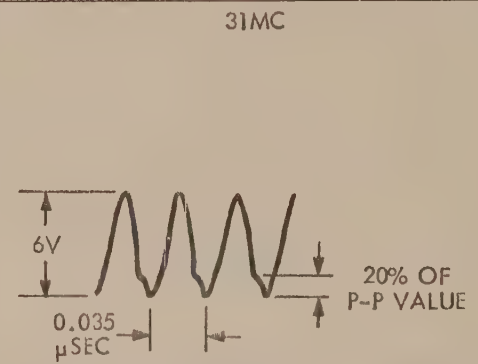
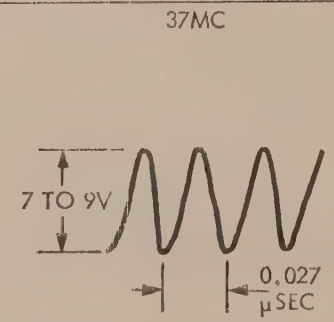
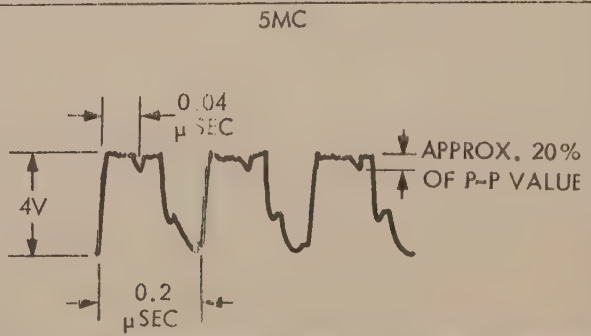
Test Procedure	Typical Waveform
Waveform 1 Test Point: TP2 Scales: Vertical - 2v/cm Sweep - .05μsec/cm Conditions: Do not use module extender because of excessive stray capacitance. See paragraph 5-5.	
Waveform 2 Test Point: TP2 Scales: Vertical - 2v/cm Sweep - .05μsec/cm Conditions: Do not use module extender. See paragraph 5-5.	
Waveform 3 Test Point: TP2 Scales: Vertical - 2v/cm Sweep - .05 μsec/cm Conditions: Do not use module extender. See paragraph 5-5.	
Waveform 4 Test Point: TP3 Scales: Vertical - 2v/cm Sweep - 0.1μsec/cm Conditions: Do not use module extender. See paragraph 5-5.	

Table 5-5. Frequency Divider Signal Tracing Chart (Continued)

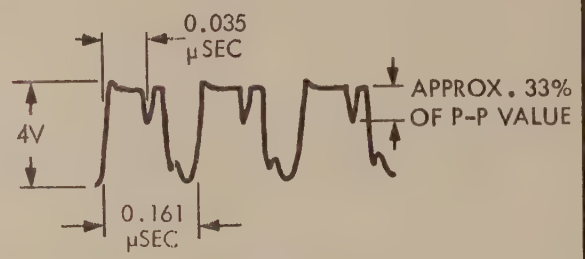
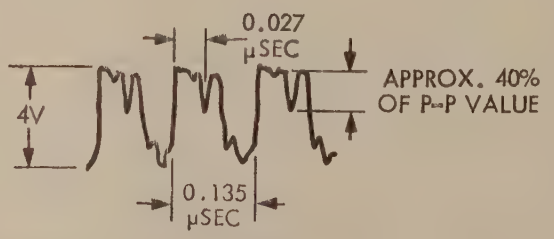
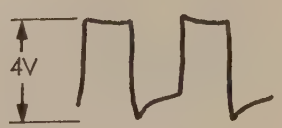
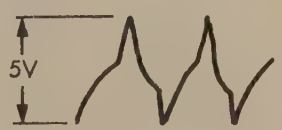
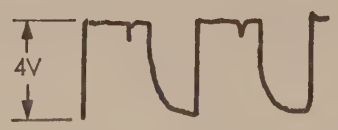
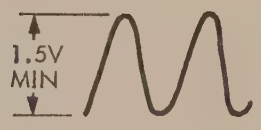
Test Procedure	Typical Waveform
Waveform 5 Test Point: TP3 Scales: Vertical - 2v/cm Sweep - 0.1μsec/cm Conditions: Do not use module extender. See paragraph 5-5.	6.2 MC 
Waveform 6 Test Point: TP3 Scales: Vertical - 2v/cm Sweep - 0.1μsec/cm Conditions: Do not use module extender. See paragraph 5-5.	7.4MC 
Waveform 7 Test Point: TP4 Scales: Vertical - 2v/cm Sweep - 0.5μsec/cm Conditions: Do not use module extender. See paragraph 5-5.	2.5MC 
Waveform 8 Test Point: TP5 Scales: Vertical - 2v/cm Sweep - 0.5μsec/cm Conditions: Do not use module extender. See paragraph 5-5.	2.5MC 

Table 5-5. Frequency Divider Signal Tracing Chart (Continued)

Test Procedure	Typical Waveform
Waveform 9 Test Point: TP6 Scales: Vertical - 2v/cm Sweep - 1μsec/cm Conditions: Do not use module extender. See paragraph 5-5.	500KC 
Waveform 10 Test Point: TP7 Scales: Vertical - 2v/cm Sweep - 2μsec/cm Conditions: Do not use module extender. See paragraph 5-5.	250KC
Waveform 11 Test Point: Module X10, pin 1 Scales: Vertical - 1v/cm Sweep - .05μsec/cm Conditions: See paragraph 5-5.	25MC 

Step 7. Install the vco divider (module X12) with its side covers removed. Repeat steps 3 through 5.

Step 8. Install the reference oscillator (module X10), and remove exposed side cover. Observe 25-mc reference signal (table 5-5, waveform 11) at pin 1 with the oscilloscope (Tektronix 581). Adjust transformers T1 and T2 for maximum voltage.

Step 9. Replace all modules and side covers.

Section 2. SPECIFICATION VERIFICATION

This section describes the procedure to be followed in verifying that the tracking filter complies with certain key specifications listed in table 1-6. This procedure will also serve as an aid in verifying that adjustments or repairs made in the unit are correct and that the unit is operating properly. This procedure presumes that all checks and adjustments called for in paragraph 5-4 have been made. Refer to table 5-1 for test equipment required.

5-6. OPEN-LOOP MEASUREMENTS.

a. FREQUENCY METER MECHANICAL ZERO. - With the power off, adjust the FREQUENCY meter for zero using the mechanical zero control under the meter face.

b. PRELIMINARY SETTINGS. - Refer to paragraph 5-4a, steps 1 through 5, for this procedure.

c. SIGNAL FREQUENCY OUTPUT.

Step 1. Connect the oscilloscope vertical input to the x1 coaxial connector on the rear panel. Allow approximately 1 minute for the system to stabilize after applying power.

Step 2. Operate the SET FREQUENCY controls while monitoring the oscilloscope to ensure that the amplitude exceeds 2.8 volts peak-to-peak for frequencies between 100 cps and 120 kc.

Step 3. Repeat step 2 while monitoring the x10 and the x100 outputs. The amplitude of the x10 output should exceed 2.8 volts peak-to-peak for frequencies between 1 kc and 1.2 mc, and the x100 output should exceed 0.75 volt peak-to-peak for frequencies between 10 kc and 12 mc. (A minimum 15 mc oscilloscope should be employed.)

d. FREQUENCY ANALOG OUTPUT.

Step 1. Connect the counter to the VCO coaxial connector on the rear panel, and adjust the vco frequency to 310 kc.

Step 2. Measure the d-c voltage at the ANAL rear panel connector with the vtvm. It should be zero volts ±0.5 volt.

Step 3. Rotate the SET FREQUENCY controls to position the vco frequency at 370 kc. The d-c level at the ANAL connector should be -10 volts ±0.5 volt.

Step 4. Rotate the SET FREQUENCY controls to position the vco frequency at 250 kc. The d-c level at the ANAL connector should be +10 volts ±0.5 volt. Rotate the FINE SET FREQUENCY control fully clockwise.

e. PHASE DETECTOR BALANCE.

Step 1. Connect an oscilloscope to the MPD coaxial connector on the rear panel and verify that the main phase detector is balanced at zero volts. The vertical sensitivity of the oscilloscope must be at least 50 mv/cm for this measurement.

Step 2. Repeat step 1 with the oscilloscope connected to the APD coaxial connector.

f. PHASE SHIFTER.

Step 1. Connect a signal generator (Hewlett-Packard 200CD, or equivalent) to the SIG IN coaxial connector on the rear panel. Adjust the frequency to approximately 20 kc and the output level to approximately 100 mv/cm.

Step 2. Connect the vertical amplifier of the oscilloscope to the MPD coaxial connector and the horizontal amplifier to the APD coaxial connector. Set the vertical and horizontal sensitivities to convenient equal scales starting with approximately 500 mv/cm.

Step 3. Adjust the SET FREQUENCY controls to give a circular presentation on the oscilloscope. If the shape of the presentation is not circular, adjust the PHASE SHIFT coil on the phase detector module for the most perfect circle.

Step 4. Press the SET/ACQ switch to acquire the signal. The dot should now be steady at approximately 330 mv to the right of d-c zero.

NOTE

The 330 mv amplitude is based on the input impedance of the Hewlett-Packard 130B oscilloscope. The voltage at the APD connector is 0.5 volt when unloaded, and accurate direct measurements require a vtvm or an oscilloscope with an input impedance of greater than 10 megohms. Both phase detector outputs must be loaded with identical impedances for this adjustment. Unbalanced loading will result in distortion of the circular oscilloscope trace.

Step 5. Leave the loop in the locked condition for the next test.

5-7. CLOSED-LOOP MEASUREMENT OF VCO CONSTANT.

Step 1. Connect the counter to the VCO coaxial connector on the rear panel, and adjust the frequency of the signal generator until the vco output frequency is exactly 270 kc.

Step 2. Connect a vtvm to the EQUALIZER OUTPUT test point on the top of the equalizer module, and adjust the SET FREQUENCY controls as required to establish zero volts. The SET FREQUENCY controls must be moved slowly to prevent loss of phase-lock.

Step 3. Adjust the frequency of the signal generator slowly to 45 kc. (The maximum tracking rate of 10 kc/sec must not be exceeded or drop-lock may occur.) The voltage at the EQUALIZER OUTPUT test point must be 1 volt ±0.15 volt. A new value may be selected for resistor R2 in the vco driver (card X1) if this measurement is out of tolerance. The proper value of the vco constant is 25 kc per volt, referred to the x1 range (250 kc to 370 kc).

5-8. TRANSIENT RESPONSE.

The transient response measurements describe in this paragraph are intended as a means for checking the closed-loop bandwidths. This is done by observing the system response to a known phase rate transient. In order to simplify the procedure, a test point (EXT FM) has been provided on the vco driver card for injection of the transient-producing signal. In addition to the test equipment called for in table 5-1, a Helipot Model T-10-A potentiometer is required for this procedure. Figure 5-4 illustrates the test setup for transient response measurements. To perform this test, proceed as follows:

Step 1. Rotate the BANDWIDTH CPS switch to 100.

Step 2. Acquire an external 20-kc signal.

Step 3. Adjust the input signal amplitude to the lowest level that will give 100-percent correlation.

Step 4. Rotate the CAL/AGC switch to SLOW.

Step 5. Connect the output (wiper to common) of the Helipot potentiometer (T-10-A) to the test point in the vco driver (card X1).

Step 6. Connect the function generator (HP202A) to the input of the potentiometer.

Step 7. Rotate the potentiometer knob to position 10.

Step 8. Set the function generator frequency for a 1-cps triangular wave with minimum output level.

Step 9. Connect the oscilloscope (HP130B) to the APD and MPD outputs as described in paragraph 5-6f, step 2, and observe that oscilloscope presentation is a dot displaced to the right of center of the screen.

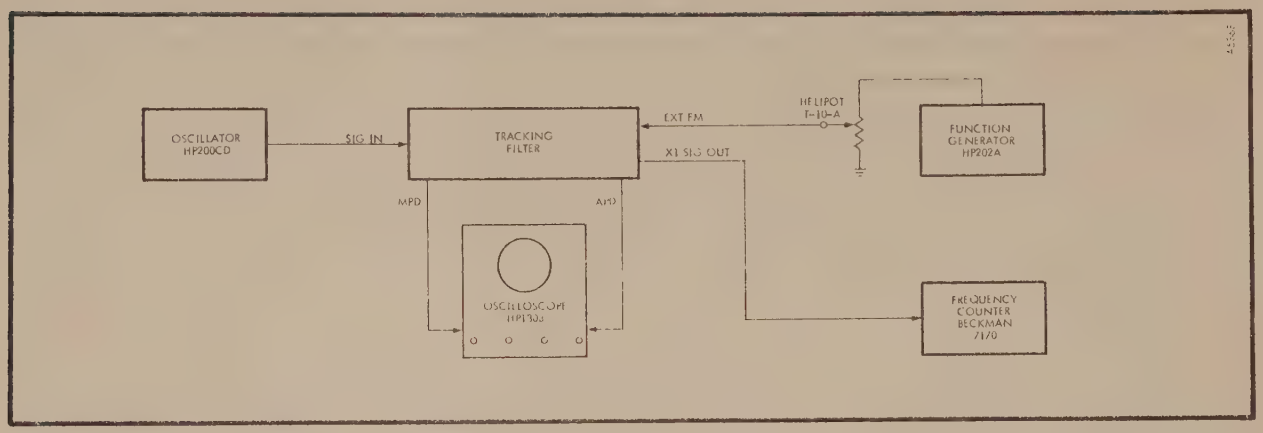


Figure 5-4. Transient Response, Test Setup

Step 10. Adjust the oscilloscope horizontal gain so that the dot is 5 cm to the right of center.

Step 11. Adjust the vertical gain for exactly the same amplitude as the horizontal gain (reversing the vertical and horizontal inputs momentarily is a simple way of doing this).

Step 12. Slowly increase the function generator output. The system transients can now be observed on the oscilloscope as the dot moves alternately above and below the horizontal center line, along an arc of a circle.

Step 13. Continue to increase the function generator output until the peaks of the transients are at points ±3.0 cm from the horizontal center line. This condition corresponds to ±30 degree transients.

Step 14. Connect the frequency counter to the x1 signal output connector.

Step 15. Change the function generator frequency to a 0.1-cps square wave.

Step 16. Press the SET/ACQ switch to SET.

Step 17. Observe that the frequency counter reading changes between two different frequency values. Record these two values, and subtract the lower one from the higher. This difference frequency is the Δf of the vco. It should be between 400 and 600 cps.

Step 18. Without changing the function generator output level, set its frequency to a 0.5-cps triangular wave.

Step 19. Set the Helipot potentiometer to 5.0 and set the BANDWIDTH CPS switch to 50.

Step 20. The loop transients observed on the oscilloscope should be ±30 degrees ±7 degrees.

Step 21. Proceed with the 25, 10, 5, and 2.5 cps bandwidth positions, using the settings shown in table 5-6.

TABLE 5-6. TRANSIENT RESPONSE DATA

Loop Bandwidth	Triangular Wave Frequency	Helipot Setting	Peak Transmit
100 cps	1 cps	10	Set for $\pm30^{O}$ $\pm7^{O}$
50 cps	0.5 cps	5	Set fro $\pm30^{O}$ $\pm7^{O}$
25 cps	0.25 cps	2.5	Set for $\pm30^{O}$ $\pm7^{O}$
10 cps	0.1 cps	1	Set for $\pm30^{O}$ $\pm7^{O}$
5 cps	0.05 cps	0.5	Set for $\pm30^{O}$ $\pm7^{O}$
2.5 cps	0.025 cps	0.25	Set for 30^{O} $\pm7^{O}$

5-9. NOISE MEASUREMENTS.

Proper input mixer balance is essential to satisfactory noise performance. Steps 6 and 7 of paragraph 5-4b can be repeated before proceeding. The test setup for noise measurements is illustrated in figure 5-5.

Step 1. Connect the output of the noise generator (GR130A) to the input of the audio amplifier (HP450A) through a 4700-ohm isolating resistor. (This isolating resistor should be located at the audio amplifier input end of the connection.)

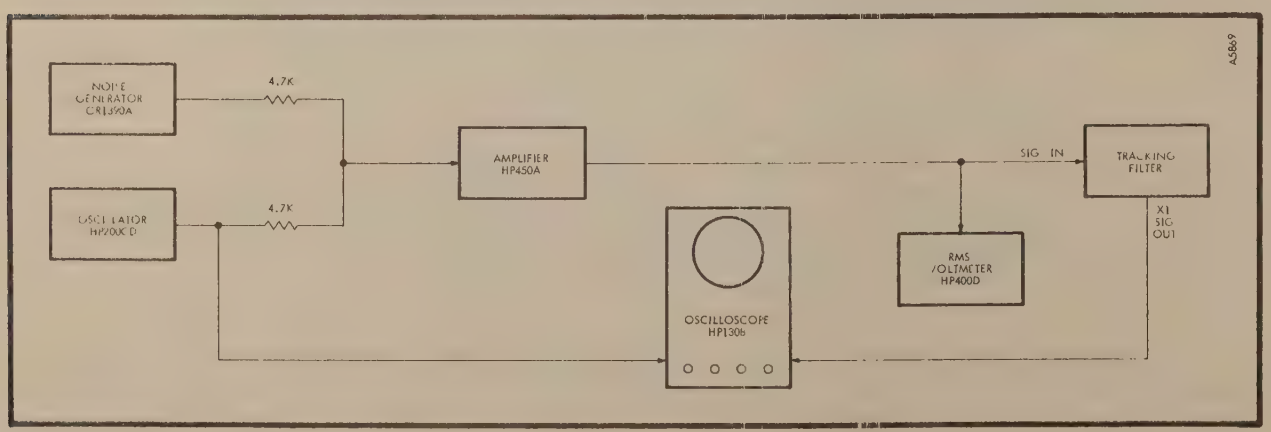


Figure 5-5. Noise Measurement, Test Setup

Step 2. Connect the audio generator to the same audio amplifier input through another 4700-ohm resistor.

Step 3. Set the noise generator bandwidth to 500 kc, and the output level to zero.

Step 4. Connect the output of the audio amplifier to the SIG IN connector of the tracking filter.

Step 5. Rotate the CAL/AGC switch to FAST.

Step 6. Rotate the BANDWIDTH CPS switch to 100.

Step 7. Set the signal generator frequency to 20 kc, and cause the tracking filter to acquire this signal.

Step 8. Connect the vertical input of the oscilloscope to the audio generator output and the horizontal input of the oscilloscope to the x1 coaxial connector on the tracking filter rear panel. Adjust the horizontal and vertical sensitivity controls on the oscilloscope to give a Lissajou's figure indicating phase correlation between the tracking filter input and output.

Step 9. Reduce the signal generator output until it just exceeds the agc threshold level, as indicated by a CORRELATION meter reading at just 100 percent.

Step 10. Connect rms voltmeter HP400D across the audio amplifier output terminals, and record the level observed.

Step 11. Slowly rotate the noise generator output control clockwise while observing the voltmeter.

Step 12. Continue to increase the noise level until the tracking filter is unable to track the input signal as indicated on the oscilloscope by a loss of input-output phase correlation. Record this new voltage level.

Step 13. Subtract this level (expressed in decibels) from the first one. This difference exceeds by 6 db the signal-to-noise ratio of the tracking filter. (The excess 6 db result from making the noise measurement over the noise generator bandwidth of 500 kc, whereas the actual noise bandwidth of interest is 120 kc. Because the effective voltage of the noise is proportional to the square root of the bandwidth and because the square root of the bandwidth ratio is the square root of the ratio of the noise bandwidth (500 kc) to input bandwidth (120 kc), an error of 6 db is introduced.

Step 14. Obtain the signal-to-noise ratio for the 100-cps bandwidth by subtracting 6 db from the value obtained. The signal-to-noise ratio for the 100-cps bandwidth should be -22 db, +1 db or -3 db.

Step 15. Proceed as above for measuring the signal-to-noise ratios of the other bandwidths. The values given in the specifications are repeated in table 5-7.

TABLE 5-7. SIGNAL-TO-NOISE RATIO

Loop Bandwidth	Signal-to-Noise Ratio	
	500-kc Noise BW	120-kc Noise BW
2.5 cps	-44 db + 1 db, -3 db	-38 db + 1 db, -3 db
5 cps	-41 db + 1 db, -3 db	-35 db + 1 db, -3 db
10 cps	-38 db + 1 db, -3 db	-32 db + 1 db, -3 db
25 cps	-34 db + 1 db, -3 db	-28 db + 1 db, -3 db
50 cps	-31 db + 1 db, -3 db	-25 db + 1 db, -3 db
100 cps	-28 db + 1 db, -3 db	-22 db + 1 db, -3 db

Chapter 6
PARTS LIST

6-1. GENERAL.

This chapter contains a list of replaceable parts for the tracking filter. Only those parts which are normally subject to electrical or mechanical failure are included. Attaching parts and other mechanical items are not listed.

Table 6-1 is a compilation of vendor code numbers, names, and addresses of manufacturers for items listed in the parts list. Code numbers used are from the Department of Defense Cataloging Handbook H4-2, Federal Supply Code for Manufacturers, dated October 1959 and current supplements.

6-2. REPLACEABLE PARTS.

The list of replaceable parts for the tracking filter follows the list of manufacturers.

The first column of the list provides the reference symbols of the parts in alpha-numeric order. The reference symbols are coded by indentation to indicate the relationship of each item to its next higher assembly.

The second column lists the item name.

The third column lists the manufacturer's part number for each part and the federal stock number, if assigned.

The fourth column lists the numerical code number designating the manufacturer of the part.

The fifth column lists the total quantity of parts per unit. The total quantity is listed only for the first entry of any item.

The sixth column lists the contents of spare parts kits.

6-3. SPARE PARTS KITS.

Two types of spare parts kits are available for Tracking Filter Models PL300 - PL307. Spares Kit Type 1 contains those items normally required for one year of service for units employed in a laboratory environment with a good local parts source. Spares Kit Type 2 contains those items

normally required for one year of service for units employed at remote locations with no rapid and reliable parts source.

The quantity of each part included in either kit is indicated in the sixth column of the parts list, where the upper number refers to the Type 1 kit, while the lower number reflects the contents of the Type 2 kit. Complete spares kits and individual parts can be ordered from the factory Marketing Department. Always indicate model and serial number of the tracking filter (and plug-in card or module where applicable) when ordering.

TABLE 6-1. LIST OF MANUFACTURERS

Code	Manufacturer
00656	Aerovox Corp., New Bedford, Massachusetts
01121	Allen-Bradley Co., Milwaukee, Wisconsin
01295	Texas Instruments, Inc., Semiconductor Components Division, Houston, Texas
02735	RCA Semiconductor and Materials Division of Radio Corp. of America, Somerville, New Jersey
03508	General Electric Co., Semi-Conductor Products, Syracuse, New York
04713	Motorola, Inc., Semiconductor Products Division, Phoenix, Arizonia
05375	Vari-L Co., Inc., Stamford, Connecticut
06978	Aladdin Electronics Division of Aladdin Industries, Inc., Nashville, Tennessee
07421	Interstate Electronics Corp., Anaheim, California
07716	International Resistance Co., Burlington, Iowa.
07910	Continental Device Corp., Hawthorne, California
12060	Diodes, Inc., Canoga Park, California
12711	Western Semiconductors, Inc., Santa Ana, California
13209	Bendix Semiconductor Division of Bendix Corp., Holmdel, New Jersey
14655	Cornell Dubilier Electric Corp., South Plainfield, New Jersey
15605	Cutler Hammer, Inc., Milwaukee Wisconsin
40931	Minneapolis-Honeywell Regulator Co., Minneapolis, Minnesota
44655	Ohmite Mfg., Skokie, Illinois
46859	Philco Corp., Philadelphia, Pennsylvania
49956	Raytheon Mfg. Co., Waltham, Massachusetts
56289	Sprague Electric Co., North Adams, Massachusetts
70309	Allied Control Co., Inc., New York, New York
71400	Bussman Fuse Division of McGraw-Edison Co., St. Louis, Missouri
71468	Cannon Electric Co., Los Angeles, California
71590	Centralab Division of Globe Union, Inc., Milwaukee, Wisconsin
72699	General Instrument Corp., Newark, New Jersey
73183	Helipot Division of Beckman Instruments, Inc., Fullerton, California

Table 6-1. List of Manufacturers (Continued)

Code	Manufacturer
73445	Amperex Electronic Co., Division of North American Philips Co., Inc., Hicksville, New York
73899	JFD Electronics Corp., Brooklyn, New York
74059	Micro Switch Corp., Freeport, Illinois
74545	Hubbell Harvey, Inc., Bridgeport, Connecticut
75376	Kurz-Kasch, Inc., Dayton, Ohio
75915	Littlefuse, Inc., Des Plaines, Illinois
76433	Micamold Electronics Mfg. Corp., Brooklyn, New York
76493	Miller, J. W., Co., Los Angeles, California
79727	Wirt Co., Philadelphia, Pennsylvania
80183	Sprague Products Co., North Adams, Massachusetts
80294	Bourns Laboratories, Inc., Riverside, California
81654	Monitor Products Company, Pasadena, California
82389	Switchcraft, Inc., Chicago, Illinois
82893	Vector Electronic Co., Glendale, California
84171	Arco Electronics, Inc., New York, New York
91506	Augat Bros., Inc., Attleboro, Massachusetts
91662	Elco Corp., Philadelphia, Pennsylvania
93332	Sylvania Electric Products, Inc., Semiconductor Division, Woburn, Massachusetts
97328	Universal Electronics Co., Santa Monica, California
99180	Transitron Electronic Corp., Melrose, Massachusetts
99217	Southern Electronics Co., Burbank, California
99515	Electron Products, Inc., Pasadena, California
99800	Delvan Electronics Corp., East Aurora, New York
99942	Hoffman Semiconductor Division of Hoffman Electronics Corp., Evanston, Illinois

NOTES

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9453	TRACKING FILTER	9453000	07421	1	
DS1	LAMP,INCAND T-1 3/4SC MID 14 V 0.08A	330	72619	7	10 20
DS2	LAMP,INCAND	330 SAME AS 9453DS1	72619	REF	
DS3	LAMP,INCAND	330 SAME AS 9453DS1	72619	REF	
F1	FUSE CARTRIDGE 1 AMP SLO-BLOW	313001	75915	1	0 1
J1	CONN,RECP ELEC	7486	74545	1	0 1
J2	CONN,RECP ELEC 10 # 16 SOCKET CONTACTS	AN3102A18-1S	71468	1	0 1
J3-J19	CONN,RECP ELEC BNC TYPE	UG625B/U	71468	17	0 1
J21	JACK,PHONE	C12A	82389	1	0 1
M1	METER,FREQ	9451220	07421	1	1 1
M2	METER,CORR	9451221	07421	1	1 1
PS1	POWER SUPPLY SEE ADDENDA FOR APPLICABLE UNIT	*NOTE		1	
R1	RES,VAR WIRE 1,000 OHMS 10% 2 WATTS	317-101-008 CLU1021	07421 44655	1	1 1
R4	RES,VAR WIRE 10,000 OHMS .25 LINEAR	AR10KL0,25	73183	1	1 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R10	RES,VAR COMP 2,500 OHMS 10% 2WATTS	CU2521	44655	1	1 1
R11,R12	RES,FXD COMP 8,200 OHMS 5% 1/4 WATT	RC07GF822J	44655	2	0 2
R23-R26	RES,FXD COMP 270 OHMS 5% 1/2 WATT	RC20GF271J	44655	4	0 2
S1	SWITCH TOGGLE	8867K4	15605	1	0 1
S6	SW-LITE ASSY	9451900-500	07421	1	1 1
S7	SW-LITE ASSY	9451900-501	07421	1	
S8	SWITCH ASSEMBLY	9451222	07421	1	0 1
S10	SWITCH ASSEMBLY	9451223	07421	1	0 1
S11	SWITCH ASSEMBLY	9451400	07421	1	0 1
S12	SW-LITE ASSY	9451900	07421	1	0 1
TB1	COMPONENT BOARD	9451600	07421	1	
C1-C5	CAP,FXD PAPER 1.0 MFD,100VDCW SPECIAL	9451020	07421	5	0 1
K1-K7	RELAY DPDT,COIL 12VDC PLUG IN	TL154CC-CC12VDC	70309	7	1 2

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R1,R2	RES,FXD COMP 47 OHMS 5% 1/2 WATT	RC20GF470J	44655	5	0 2
R3	RES,FXD COMP 10,000 PHMS 5% 1/2 WATT	RC20GF103J	44655	1	0 1
R4	RES,FXD COMP	RC20GF470J SAME AS 9453R1	44655	REF	
R5	RES,FXD COMP 150,000 OHMS 5% 1/2 WATT	RC20GF154J	44655	1	0 1
R6,R7	RES,FXD COMP	RC20GF470J SAME AS 9453R1	44655	REF	
R8	RES,FXD COMP 4,700 OHMS 5% 1/2 WATT	RC20GF472J	44655	1	0 1
TB2	COMPONENT BOARD	9451800	07421	1	
C1	CAP,FXD PAPER 1.0 MFD 10% 100 VDCW	323-001-040 WE1-105E	07421 99515	1	0 2
C2	CAP,FXD MICA 3000 MMF 5% 500 VDCW	321-002-039 DM19-302J	07421 84171	1	0 1
C3	CAP,FXD PAPER 0.010MFD 10% 100 VDCW	323-001-013 WE1-103E	07421 99515	1	0 2
C4,C5	CAP,FXD PAPER 0.10 MFD 10% 100 VDCW	323-001-025 WE1-104E	07421 99515	2	0 10
C6	CAP,FXD MICA 2400 MMF 5% 500 VDCW	321-003-014 DM20-242J	07421 84171	1	0 1
C7	CAP,FXD MICA 270 MMF 5% 500VDCW	321-001-038 DM15-271J	07421 84171	1	0 1
CR1	SEMICONDUCTOR	S555G	03877	1	1 2

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
[illegible]	CRYSTAL	9451320	07421	1	2 4
[illegible]	[illegible]	6308	76493	2	0 1
[illegible]	TRANSISTOR	2N2270	02735	1	5 10
R1	RES,FXD COMP 680 OHMS 5% 1/4 WATT	RC07GF681J	44655	1	0 1
[illegible]	RES,FXD COMP 43 OHMS 5% 1/4 WATT	RC07GF430J	44655	1	0 1
[illegible]	RES,FXD COMP 100,000 OHMS 5% 1/4 WATTS	RC07GF104J	44655	2	0 3
[illegible]	RES,FXD COMP 150 OHMS 5% 1/4 WATT	RC07GF151J	44655	1	0 1
[illegible]	RES,FXD COMP 100 OHMS 5% 1/4 WATTS	RC07GF101J	44655	1	0 6
[illegible]	RES,FXD COMP 30,000 OHMS 5% 1/4 WATT	RC07GF303J	44655	2	0 2
[illegible]	RES,FXD COMP 390,000 OHMS 5% 1/4 WATT	RC07GF394J	44655	1	0 2
[illegible]	RES,FXD COMP 150,000 OHMS 5% 1/4 WATT	RC07GF154J	44655	1	0 1
R10	RES,FXD COMP	RC07GF303J SAME AS 9453R7	44655	REF	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R11	RES,FXD COMP 10,000 OHMS 5% 1/4 WATTS	RC07GF103J	44655	1	0 8
XF1	FUSEHOLDER 1/4 WATT	HKP	71400	1	0 1
09	SWITCH ASSEMBLY	9452600	07421	1	
9470	BOARD ASSEMBLY	9470000	07421	1	
C1	CAP,FXD MICA 10,000 MMF 5% 100 VDCW	321-003-031 DM20-103J	07421 84171	1	0 1
C2	CAP,FXD MI A 5,100 MMF 5% [illegible] VV- T	DM20-512J	84171	1	0 1
C3	CAP,FXD MICA 2,700 MMF 5% [illegible] VV- T	DM20-272J	84171	1	0 1
C4	CAP,FXD MICA 1000 MMF 5% 100 VDCW	321-001-053 DM15-102J	07421 84171	1	0 1
C5	CAP,FXD MICA 330 MMF 5% 500VDCW	321-001-040 DM15-331J	07421 84171	1	0 1
R1-R5	RES,FXD COMP 22MEG OHMS 5% 1/2 WATT	RC20GF226J	44655	5	0 2
R6	RES,FXD COMP 43,000 OHMS 5% 1/2 WATT	RC20GF433J	44655	1	0 1
R7	RES,FXD COMP 62,000 OHMS 5% 1/2 WATT	RC20GF623J	44655	1	0 1
R9	RES,FXD COMP 3,000 OHMS 5% 1/4 WATT	RC07GF302J	44655	1	0 2

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R10	RES,FXD COMP 11,000 OHMS 5% 1/4 WATT	RC07GF113J	44655	4	0 1
R11	RES,FXD COMP 560 OHMS 5% 1/4 WATT	RC07GF561J	44655	1	0 1
R14	RES,FXD COMP	RC07GF113J SAME AS 9453R10	44655	REF	
R15	RES,FXD COMP 18,000 OHMS 5% 1/4 WATT	RC07GF183J	44655	1	0 1
R16,R17	RES,FXD COMP	RC07GF113J SAME AS 9453R10	44655	REF	
R18	RES,FXD FILM 634 OHMS 1% 1/8 WATT	312-001-127 MEA/TO-	07421 07716	1	0 1
R19	RES,FXD FILM 1270 OHMS 1% 1/8 WATT	312-001-156 MEA/TO-1271F	07421 07716	1	0 1
R20	RES,FXD FILM 2550 OHMS 1% 1/8 WATT	312-001-185 MEA/TO-2551F	07421 07716	1	0 1
R21	RES,FXD FILM 6340 OHMS 1% 1/8 WATT	312-001-223 MEA/TO-6341F	07421 07716	1	0 1
R22	RES,FXD FILM 12,700 OHMS 1% 1/8 WATT	312-001-252 MEA/TO-1272F	07421 07716	1	0 1
R23	RES,FXD FILM 25,500 OHMS 1% 1/8 WATT	312-001-281 MEA/TO-2552F	07421 07716	1	0 1
R24	RES,FXD FILM 4.32MEG OHMS 1% 1/8 WATT	312-003-590 MDA-4324F	07421	2	0 1
R25	RES,FXD FILM 2.05MEG OHMS 1% 1/8 WATT	312-003-559 MDA-2054F	07421	2	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R26	RES,FXD FILM 1.33MEG OHMS 1% 1/8 WATT	312-003-541 MDA-1334F	07421	1	0 1
R27	RES,FXD FILM 634,000 OHMS 1% 1/8 WATT	312-003-510 MDA-6343F	07421	1	0 1
R28	RES,FXD COMP 324,000 OHMS 1% 1/8 WATT	312-001-387 MEA/TO-3243F	07421 07716	1	0 1
R29	RES,FXD FILM	312-003-590 SAME AS 9453R24	07421	REF	
R30	RES,FXD FILM	312-003-559 SAME AS 9453R25	07421	REF	
R31	RES,FXD COMP 442,000 OHMS 1% 1/8 WATT	312-001-400 MEA/TO-4423F	07421 07716	1	0 1
R32	RES,FXD FILM 59,000 OHMS 1% 1/8 WATT	312-001-316 MEA/TO-5902F	07421 07716	1	0 1
R33	RES,FXD FILM 14,700 OHMS 1% 1/8 WATT	312-001-258 MEA/TO-1472F	07421 07716	1	0 1
R34	RES,FXD FILM 3650 OHMS 1% 1/8 WATT	312-001-200 MEA/TO-3651F	07421 07716	1	0 1
R35	RES,FXD COMP 178,000 OHMS 1% 1/8 WATT	312-001-362 MEA/TO-1783F	07421 07716	1	0 1
R36	RES,FXD COMP 90,900 OHMS 1% 1/8 WATT	312-001-334 MEA/TO-9092F	07421 07716	1	0 1
R37	RES,FXD FILM 44,200 OHMS 1% 1/8 WATT	312-001-304 MEA/TO-4422F	07421 07716	1	0 1
R38	RES,FXD FILM 17,800 OHMS 1% 1/8 WATT	312-001-266 MEA/TO-1782F	07421 07716	1	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R39	RES,FXD FILM 8870 OHMS 1% 1/8 WATT	312-001-237 MEA/TO-8871F	07421 07716	1	0 1
R40	RES,FXD FILM 4420 OHMS 1% 1/8 WATT	312-001-208 MEA/TO-4421F	07421 07716	1	0 1
R41	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	R 1	
R42	RES,FXD COMP 5,100 OHMS 5% 1/4 WATT	RC07GF512J	44655	2	0 2
R43,R44	RES,FXD COMP 4,700 OHMS 5% 1/4 WATT	RC07GF472J	44655	2	0 3
R45	RES,FXD COMP	RC07GF512J SAME AS 9453R42	44655	REF	
R46	RES,FXD COMP 3,900 OHMS 5% 1/4 WATT	RC07GF392J	44655	1	0 1
9474	BOARD ASSEMBLY	9474000	07421	1	0 1
C1	CAP,FXD PAPER	323-001-025 SAME AS 9453C4	07421	R 1	
C2,C3	CAP,FXD ELECT TANTALUM TYPE 2 MFD 25 VDCW	322-004-201 30D176A1	07421 56289	2	0 2
C4	CAP,FXD ELECT TANTALUM TYPE 25 MFD 25 VDCW	322-004-208 30D184A1	07421 56289	1	0 1
C5	CAP,FXD PAPER	323-001-040 SAME AS 9453C1	07421	R 1	
C6	CAP,FXD ELECT TANTALUM TYPE 50 MFD 25 VDCW	322-004-210 30D186A1	07421 56289	1	0 1
Q1	TRANSISTOR	345-121-001 2N652	07421 04713	3	4 8

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
Q2	TRANSISTOR	2N1485	02735	1	2 4
Q3,Q4	TRANSISTOR	345-121-001 SAME AS 9453Q1	07421	REF	
Q5	TRANSISTOR	2N670	02735	1	2 4
R1	RES,FXD COMP	RC07GF472J SAME AS 9453R43	44655	R 1	
R2	RES,FXD COMP 5,600 OHMS 5% 1/4 WATT	RC07GF562J	44655	1	0 2
R3	RES,FXD COMP	RC07GF183J SAME AS 9453R15	44655	R 1	
R4	RES,FXD COMP 12,000 OHMS 5% 1/4 WATT	RC07GF123J	44655	2	0 2
R5,R6	RES,FXD COMP 51,000 OHMS 5% 1/4 WATT	RC07GF513J	44655	2	0 2
R7	RES,FXD COMP	RC07GF512J SAME AS 9453R42	44655	R 1	
R8	RES,FXD COMP 1MEG OHMS 5% 1/4 WATTS	RC07GF105J	44655	1	0 1
R9	RES,FXD COMP 6,800 OHMS 5% 1/4 WATT	RC07GF682J	44655	1	0 3
R10	RES,ADJ IRE 500 OHMS 10% 1 WATT	315-004-006 260P1-501	07421 84171	1	1 1
R11	RES,ADJ WIRE 25,000 OHMS 10% 1 WATT	315-004-012 260P1-253	07421 84171	1	1 1
R12	RES,FXD COMP 27,000 OHMS 5% 1/4 WATT	RC07GF273J	44655	1	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R13	RES,FXD COMP	RC07GF822J SAME AS 9453R11	44655	R 2	
R14	RES,FXD COMP 2,000 OHMS 5% 1 WATT	RC32GF202J	44655	1	0 1
R15	RES,FXD COMP	RC07GF123J SAME AS 9453R4	44655	REF	
R16	RES,FXD COMP 20,000 OHMS 5% 1/4 WATT	RC07GF203J	44655	1	0 2
R18	RES,FXD COMP 820 OHMS 5% 1/4 WATT	RC07GF821J	44655	2	0 2
R19	RES,FXD COMP 33 OHMS 5% 1/4 WATT	RC07GF330J	44655	1	0 1
R20	RES,FXD COMP 36 OHMS 5% 1/4 WATT	RC07GF360J	44655	1	0 1
R21	RES,FXD COMP 51 OHMS 5% 1/4 WATT	RC07GF510J	44655	1	0 4
R22	RES,FXD COMP 110 OHMS 5% 1/4 WATTS	RC07GF111J	44655	1	0 1
R23	RES,FXD COMP 130 OHMS 5% 1/4 WATT	RC07GF131J	44655	1	0 1
R24	RES,FXD COMP	RC07GF821J SAME AS 9453R18	44655	REF	
R25	RES,FXD COMP 1,600 OHMS 5% 1/4 WATT	RC07GF162J	44655	1	0 1
R26	RES,FXD COMP 390 OHMS 5% 1/4 WATT	RC07GF391J	44655	1	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R27	RES,FXD COMP 39,000 OHMS 5% 1/4 WATT	RC07GF393J	44655	1	01
R28	RES,FXD COMP 36,000 OHMS 5% 1/4 WATT	RC07GF363J	44655	1	01
R29	RES,FXD COMP	RC07GF104J SAME AS 9453R3	44655	R 1	
R30	RES,FXD COMP 24,000 OHMS 5% 1/4 WATT	RC07GF243J	44655	1	01
R31	RES,FXD COMP 1,300 OHMS 5% 1/4 WATT	RC07GF132J	44655	1	01
R32	RES,FXD COMP 1000 OHMS 5% 1/4 WATTS	RC07GF102J	44655	1	09
R33	RES,FXD COMP 82,000 OHMS 5% 1/4 WATT	RC07GF823J	44655	1	01
R34	RES,FXD COMP	RC07GF822J SAME AS 9453R11	44655	REF	
R34	RES,FXD COMP 1,500 OHMS 5% 1/4 WATT	RC07GF152J	44655	1	01
R36	RES,FXD COMP 330 OHMS 5% 1/4 WATT	RC07GF331J	44655	1	02
R37	RES,FXD COMP 22,000 OHMS 5% 1/4 WATT	RC07GF223J	44655	1	02
R38	RES,FXD COMP 1,100 OHMS 5% 1/4 WATT	RC07GF112J	44655	3	01
R39	RES,FXD COMP 2,000 OHMS 5% 1/4 WATT	RC07GF202J	44655	1	03

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R40	RES,FXD COMP 220 OHMS 5% 1/4 WATT	RC07GF221J	44655	1	0 1
R41,R42	RES,FXD COMP	RC07GF112J SAME AS 9453R38	44655	REF	
TR1	THERMISTOR	35TF2	09052	1	1 2
34	KNOB	70-8WL2	49956	1	
52	POWER CORD	16200067	07421	1	0 1
53	TEST ADAPTER	9452400	07421	1	0 1
54	TEST ADAPTER	9452500	07421	1	0 1
55	CONN,PLUG ELEC 10 # 16 PIN CONTACTS	AN3106A18-1P	71468	1	0 1
56	CONN,PLUG ELEC BNC TYPE	UG88/U	71468	17	0 1
58	LAMP TOOL	15PA32	40931	1	0 1
74	RES,ADJ IRE 500 OHMS 5% 1/2 WATT	315-003-002 3367P1-201	07421 80294	1	1 1
	CAP,FXD PAPER 2.0 MFD 10% 100 VDCW	323-001-042 WE1-205E	07421 99515	2	0 2
	KNOB KNOB KNOB	125-6-2 S645-5L S645-3L	49936 75376 75376	1 1 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
	KNOB	S647-3L	75376	2	
	KNOB	S656-3L	75376	1	
9460	MODULE ASSEMBLY	9460000	07421	1	
461-502	MODULE ASSEMBLY	9461000-502	07421	1	
9462	MODULE ASSEMBLY	9462000	07421	1	
9463-501	MODULE ASSEMBLY	9463000-501	07421	1	
9464	MODULE ASSEMBLY	9464000	07421	1	
9466	MODULE ASSEMBLY	9466000	07421	2	
9468	MODULE ASSEMBLY	9468000	07421	1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9453-500	TRACKING FILTER	9453000-500	07421	1	
DS2	LAMP,INCAND	330	72619	R 2	
		SAME AS 9453DS1			
S7	SW-LITE ASSY	9451900-501	07421	R 1	
	KNOB	S645-5L	75376	R 2	
	KNOB	S656-3L	75376	R 2	
94527	SWITCH ASSEMBLY	9452700	07421	1	
9460	MODULE ASSEMBLY	9460000	07421	R 1	
9461-503	MODULE ASSEMBLY	9461000-503	07421	1	
9462	MODULE ASSEMBLY	9462000	07421	R 1	
9463-501	MODULE ASSEMBLY	9463000-501	07421	R 1	
9464	MODULE ASSEMBLY	9464000	07421	R 1	
9465	MODULE ASSEMBLY	9465000	07421	1	
9466	MODULE ASSEMBLY	9466000	07421	R 1	
9468	MODULE ASSEMBLY	9468000	07421	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9453-501	TRACKING FILTER	9453000-501	07421	1	
DS2	LAMP, INCAND	330	72619	R 4	
		SAME AS 9453DS1			
S7	SW-LITE ASSY	9451900-502	07421	1	
9460	MODULE ASSEMBLY	9460000	07421	R 1	
9461-503	MODULE ASSEMBLY	9461000-503	07421	R 1	
9462	MODULE ASSEMBLY	9462000	07421	R 1	
9463-501	MODULE ASSEMBLY	9463000-501	07421	R 1	
9464	MODULE ASSEMBLY	9464000	07421	R 1	
9466	MODULE ASSEMBLY	9466000	07421	R 2	
9467	MODULE ASSEMBLY	9467000	07421	1	
9468	MODULE ASSEMBLY	9468000	07421	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9453-502	TRACKING FILTER	9453000-502	07421	1	
DS2	LAMP, INCAND	330	72619	R 2	
		SAME AS 9453DS1			
S7	SW-LITE ASSY	9451900-501	07421	R 1	
9460	MODULE ASSEMBLY	9460000	07421	R 1	
9461-502	MODULE ASSEMBLY	9461000-502	07421	R 1	
9462	MODULE ASSEMBLY	9462000	07421	R 1	
9463-501	MODULE ASSEMBLY	9463000-501	07421	R 1	
9464	MODULE ASSEMBLY	9464000	07421	R 1	
9466	MODULE ASSEMBLY	9466000	07421	R 1	
9468	MODULE ASSEMBLY	9468000	07421	R 1	
9469	MODULE ASSEMBLY	9469000	07421	1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9453-503	TRACKING FILTER	9453000-503	07421	1	
DS2	LAMP, INCAND	330	72619	R 2	
		SAME AS 9453DS1			
S7	SW-LITE ASSY	9451900-501	07421	R 1	
	KNOB	S645-5L	75376	R 2	
	KNOB	S656-3L	75376	R 2	
94527	SWITCH ASSEMBLY	9452700	07421	R 1	
9460	MODULE ASSEMBLY	9460000	07421	R 1	
9461-503	MODULE ASSEMBLY	9461000-503	07421	R 1	
9462	MODULE ASSEMBLY	9462000	07421	R 1	
9463-501	MODULE ASSEMBLY	9463000-501	07421	R 1	
9464	MODULE ASSEMBLY	9464000	07421	R 1	
9465	MODULE ASSEMBLY	9465000	07421	R 1	
9466	MODULE ASSEMBLY	9466000	07421	R 2	
9468	MODULE ASSEMBLY	9468000	07421	R 1	
9469	MODULE ASSEMBLY	9469000	07421	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9453-504	TRACKING FILTER	9453000-504	07421	1	
DS2	LAMP, INCAND	330	72619	R 4	
		SAME AS 9453DS1			
S7	SW-LITE ASSY	9451900-502	07421	R 1	
	KNOB	S645-5L	75376	R 2	
	KNOB	S656-3L	75376	R 2	
94527	SWITCH ASSEMBLY	9452700	07421	R 1	
9460	MODULE ASSEMBLY	9460000	07421	R 1	
9461-504	MODULE ASSEMBLY	9461000-504	07421	1	
9462	MODULE ASSEMBLY	9462000	07421	R 1	
9463-501	MODULE ASSEMBLY	9463000-501	07421	R 1	
9464	MODULE ASSEMBLY	9464000	07421	R 1	
9465	MODULE ASSEMBLY	9465000	07421	R 1	
9466	MODULE ASSEMBLY	9466000	07421	R 2	
9467	MODULE ASSEMBLY	9467000	07421	R 1	
9468	MODULE ASSEMBLY	9468000	07421	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9453-505	TRACKING FILTER	9453000-505	07421	1	
DS2	LAMP, INCAND	330	72619	R 4	
		SAME AS 9453DS1			
S7	SN-LITE ASSY	9451900-502	07421	R 1	
9460	MODULE ASSEMBLY	9460000	07421	R 1	
9461-503	MODULE ASSEMBLY	9461000-503	07421	R 1	
9462	MODULE ASSEMBLY	9462000	07421	R 1	
9463-501	MODULE ASSEMBLY	9463000-501	07421	1	
9464	MODULE ASSEMBLY	9464000	07421	R 1	
9466	MODULE ASSEMBLY	9466000	07421	R 2	
9467	MODULE ASSEMBLY	9467000	07421	R 1	
9468	MODULE ASSEMBLY	9468000	07421	R 1	
9469	MODULE ASSEMBLY	9469000	07421	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9453-506	TRACKING FILTER	9453000-506	07421	1	
DS2	LAMP,INCAND	330 SAME AS 9453DS1	72619	R 4	
S7	SW-LITE ASSY	9451900-502	07421	R 1	
	KNOB	S645-5L	75376	R 2	
	KNOB	S656-3L	75376	R 2	
94527	SWITCH ASSEMBLY	9452700	07421	R 1	
9460	MODULE ASSEMBLY	9460000	07421	R 1	
9461-503	MODULE ASSEMBLY	9461000-503	07421	R 1	
9462	MODULE A SEMBLY	9462000	07421	R 1	
9464	MODULE ASSEMBLY	9464000	07421	R 1	
9465	MODULE ASSEMBLY	9465000	07421	R 1	
9466	MODULE ASSEMBLY	9466000	07421	R 2	
9467	MODULE ASSEMBLY	9467000	07421	R 1	
9468	MODULE ASSEMBLY	9468000	07421	R 1	
9469	MODULE ASSEMBLY	9469000	07421	R 1	
9463-501	MODULE ASSEMBLY	9463000-501	07421	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9460	MODULE ASSEMBLY	9460000	07421	1	0 1
C1	CAP.FXD MICA 470 MMF 5% 300 VDCW	321-001-044 DM15-471J	07421 84171	4	0 1
C2	CAP.VAR GLASS 1/4 WATT	DS443	73899	1	1 1
C3	CAP.FXD MICA	321-001-038 SAME AS 9453C7	07421	R 1	
C5	CAP.FXD MICA	321-001-044 SAME AS 9460C5	07421	REF	
C6-C10	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	R 12	
C11	CAP.FXD MICA 130 MMF 5% 500VDCW	321-001-030 DM15-131J	07421 84171	1	0 1
C12	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C13	CAP.VAR CERAMIC 7 TO 45MMF	CV11D450	72982	1	0 1
C14	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C15	CAP.FXD PAPER	323-001-040 SAME AS 9453C1	07421	R 2	
C16,C17	CAP.FXD MICA	321-001-044 SAME AS 9460C5	07421	REF	
C18	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C19	CAP.FXD MICA 1,200 MMF 5% B VV- T	DM19-122J	84171	1	0 1
C20-C22	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C23	CAP.FXD PAPER	323-001-040 SAME AS 9453C1	07421	REF	
C24	CAP.FXD MICA	321-001-040 SAME AS 9453C5	07421	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
C25	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C26	CAP.FXD PAPER 0.047MFD 10% 100 VDCW	323-001-021 WE1-473E	07421 99515	1	0 1
CR1,CR2	SEMICONDUCTOR	1N3067	07263	2	2 4
CR3,CR4	SEMICONDUCTOR	1N99	73293	2	2 4
CR5	SEMICONDUCTOR	1N270	46859	1	2 4
L1,L2	INDUCTOR	6302	83775	2	0 1
L3	INDUCTOR	2500-32	99800	1	0 1
Q1	TRANSISTOR	2N404	02735	1	2 4
Q2	TRANSISTOR	2N384	02735	1	2 4
Q3	TRANSISTOR	2N2270 SAME AS 9453Q1	02735	R 2	
Q4	TRANSISTOR	345-121-001 SAME AS 9453Q1	07421	R 1	
Q5	TRANSISTOR	2N2270 SAME AS 9453Q1	02735	REF	
R1	RES,ADJ IRE 10,000 OHMS 10% 1 WATT	315-004-010 260P1-103	07421 84171	1	1 2
R2	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	R 2	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R3	RES,FXD COMP	RC07GF302J SAME AS 9453R9	44655	R 2	
R4	RES,FXD COMP 43,000 OHMS 5% 1/4 WATT	RC07GF433J	44655	2	0 1
R5	RES,FXD COMP	RC07GF822J SAME AS 9453R11	44655	R 1	
R6	RES,VAR COMP 100 OHMS 10% LOCKING SHAFT	AS3601	44655	1	1 1
R7,R8	RES,FXD FILM 2000 OHMS 1% 1/8 WATT	312-001-175 MEA/TO-2001F	07421 07716	2	0 1
R9	RES,FXD COMP	RC07GF433J SAME AS 9460R4	44655	REF	
R10	RES,FXD COMP	RC07GF302J SAME AS 9453R9	44655	REF	
R11	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	R 2	
R12	RES,FXD COMP	RC07GF123J SAME AS 9453R4	44655	R 2	
R13	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R14	RES,FXD COMP	RC07GF562J SAME AS 9453R2	44655	R 1	
R15	RES,FXD COMP	RC07GF512J SAME AS 9453R42	44655	R 1	
R16	RES,FXD COMP 430 OHMS 5% 1/4 WATT	RC07GF431J	44655	1	0 1
R17	RES,FXD COMP	RC07GF682J SAME AS 9453R9	44655	R 2	
R18	RES,FXD COMP	RC07GF821J SAME AS 9453R18	44655	R 2	
R19	RES,FXD COMP 15 OHMS 5% 1/4 WATT	RC07GF150J	44655	2	4 8
R20	RES,FXD COMP	RC07GF123J SAME AS 9453R4	44655	REF	
R21	RES,FXD COMP	RC07GF154J SAME AS 9453R9	44655	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R22	RES,FXD COMP 220,000 OHMS 5% 1/4 WATT	RC07GF224J	44655	1	0 1
R23,R24	RES,FXD COMP 33,000 OHMS 5% 1/4 WATT	RC07GF333J	44655	2	0 2
R25	RES,FXD COMP	RC07GF221J SAME AS 9453R40	44655	R 1	
R26	RES,FXD COMP	RC07GF682J SAME AS 9453R9	44655	REF	
R27	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R28	RES,FXD COMP	RC07GF821J SAME AS 9453R18	44655	REF	
R29	RES,FXD COMP	RC07GF150J SAME AS 9460R19	44655	REF	
R30	RES,FXD COMP	RC07GF183J SAME AS 9453R15	44655	R 1	
R31,R32	RES,FXD COMP 62,000 OHMS 5% 1/4 WATT	RC07GF623J	44655	4	0 2
R33	RES,FXD COMP	RC07GF394J SAME AS 9453R8	44655	R 2	
R34	RES,FXD COMP	RC07GF623J SAME AS 9460R31	44655	REF	
R35	RES,FXD COMP	RC07GF394J SAME AS 9453R8	44655	REF	
R36	RES,FXD COMP	RC07GF623J SAME AS 9460R31	44655	REF	
R37	RES,FXD COMP	RC07GF105J SAME AS 9453R8	44655	R 1	
R38	RES,FXD COMP 200,000 OHMS 5% 1/4 WATT	RC07GF204J	44655	1	0 1
T1	TRANSFORMER	58-123-09	80483	1	0 1
T2	TRANSFORMER	9460120	07421	1	1 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
T3	TRANSFORMER	9460120-1	07421	1	1 1
T4	TRANSFORMER	9460120-2	07421	2	1 1
T5	TRANSFORMER	9460121	07421	1	1 1
T6	TRANSFORMER	9460120-2 SAME AS 9460T4	07421	REF	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9461-502/3/4	MODULE ASSEMBLY	9461000-502/3/4	07421	1	
C1,C2	CAP.FXD MICA 3,000 MMF 5% B VV- T	DM20-302J	84171	4	0 1
C3	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	R 11	
C4	CAP.FXD MICA 3,600 MMF 5% B VV- T	DM20-362J	84171	2	0 1
C5	CAP.FXD PAPER	323-001-040 SAME AS 9453C1	07421	R 2	
C6,C7	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C8,C9	CAP.FXD MICA 1000 MMF 5% 500 VDCW	321-003-005 DM20-122J	07421 84171	2	0 1
C10,C11	CAP.FXD MICA	DM20-302J SAME AS 9461C1	84171	REF	
C12	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C13	CAP.FXD MICA	DM20-362J SAME AS 9461C4	84171	REF	
C14	CAP.FXD PAPER	323-001-040 SAME AS 9453C1	07421	REF	
C15-C20	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C21	CAP.FXD MICA 750 MMF 5% 300 VDCW	321-001-050 DM15-751J	07421 84171	1	0 1
C22	CAP.FXD MICA	DM20-512J SAME AS 9453C2	84171	R 1	
C23	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C24	CAP.FXD MICA 150 MMF 5% 500VDCW	321-001-031 DM15-151J	07421 84171	1	0 1
C25	CAP.FXD MICA 75 MMF5% 500VDCW	321-001-024 DM15-750J	07421 84171	1	0 1
C26	CAP.FXD MICA 62 MMF5% 500VDCW	321-001-022 DM15-620J	07421 84171	1	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
	CR1-CR4 PAIR SEMICONDUCTOR	9461120	07421	6	2
		1N643MATCHED PAIR	02195		4
	CR6-CR13PAIR SEMICONDUCTOR	9461120	07421	REF	
		SAME AS 9461CR1			
L1	INDUCTOR	41A334CB1	83775	1	0
					1
Q1	TRANSISTOR	2N2270	02735	R 2	
		SAME AS 9453Q1			
Q2	TRANSISTOR	345-121-001	07421	R 4	
		SAME AS 9453Q1			
Q3	TRANSISTOR	2N2270	02735	REF	
		SAME AS 9453Q1			
Q4-Q6	TRANSISTOR	345-121-001	07421	REF	
		SAME AS 9453Q1			
R1,R2	RES,FXD COMP	RC07GF474J	44655	4	0
	470,000 OHMS 5%				1
	1/4 WATT				
R3	RES,VAR COMP	AS3605	44655	2	1
	2,500 OHMS 1/2W				1
	LOCKING SHAFT				
R4,R5	RES,FXD FILM	312-001-242	07421	12	0
	10,000 OHMS 1%	MEA/TO-1002F	07716		4
	1/8 WATT				
R6	RES,FXD COMP	RC07GF752J	44655	2	0
	7,500 OHMS 5%				2
	1/4 WATT				
R7	RES,FXD COMP	RC07GF302J	44655	R 2	
		SAME AS 9453R9			
R8	RES,FXD COMP	RC20GF200J	44655	2	4
	20 OHMS 5%				8
	1/2 WATT				
R9,R10	RES,FXD COMP	RC07GF122J	44655	5	0
	1,200 OHMS 5%				1
	1/4 WATT				
R11	RES,FXD COMP	RC07GF621J	44655	2	0
	620 OHMS 5%				1
	1/4 WATT				

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R12	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	R 2	
R13,R14	RES,FXD COMP	RC07GF474J SAME AS 9461R1	44655	REF	
R15	RES,VAR COMP	AS3605 SAME AS 9461R3	44655	REF	
R16,R17	RES,FXD FILM	312-001-242 SAME AS 9461R4	07421	REF	
R18	RES,FXD COMP	RC07GF752J SAME AS 9461R6	44655	REF	
R19	RES,FXD COMP	RC07GF302J SAME AS 9453R9	44655	REF	
R20	RES,FXD COMP	RC20GF200J SAME AS 9461R8	44655	REF	
R21,R22	RES,FXD COMP	RC07GF122J SAME AS 9461R9	44655	REF	
R23	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	R 3	
R24	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	REF	
R25	RES,FXD COMP	RC07GF122J SAME AS 9461R9	44655	REF	
R26	RES,FXD COMP	RC07GF621J SAME AS 9461R11	44655	REF	
R27	RES,FXD COMP	RC07GF752J SAME AS 9461R6	44655	R 1	
R28	RES,FXD COMP 120,000 OHMS 5% 1/4 WATT	RC07GF124J	44655	1	0 1
R29	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R30	RES,FXD COMP 2,200 OHMS 5% 1/4 WATT	RC07GF222J	44655	1	0 1
R31,R32	RES,FXD COMP	RC07GF203J SAME AS 9453R16	44655	R 2	
R33	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R34	RES,FXD COMP	RC07GF221J SAME AS 9453R34	44655	R 1	
R35-R42	RES,FXD FILM	312-001-242 SAME AS 9461R4	07421	REF	
T1,T2	TRANSFORMER	58-148-02	80483	2	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
T3	TRANSFORMER	9460120-3	07421	1	1 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9462	MODULE ASSEMBLY	9462000	07421	1	0 1
C1	CAP.FXD PLASTIC 5 MFD 1/4 WATT	MMC505J1.5AE	99217	1	0 1
C3	CAP.FXD PLASTIC 10MFD 1/4 WATT	MMC106J1.5AE	99217	1	0 1
C4	CAP.FXD PAPER 0.10 MFD 10% 200 VDCW	323-001-225 WE2-104E	07421 99515	1	0 1
C5	CAP.FXD PAPER TANTALUM TYPE 6MFD.6 VDCW	323-004-051 30D126A1	07421 56289	1	0 1
C6	CAP.FXD ELECT TANTALUM TYPE 110 MFD 10 VDCW	322-002-111 151D117X9010Z2	07421 56289	1	0 1
C7	CAP.FXD PAPER 0.047MFD 10% 200 VDCW	323-001-221 WE2-473E	07421 99515	1	0 1
C8	CAP.FXD PAPER 0.47 MFD 10% 100 VDCW	323-001-034 WE1-474E	07421 99515	3	0 2
C9	CAP.FXD ELECT TANTALUM TYPE 22 MFD 15 VDCW	322-001-154 150D226X9015B2	07421 56289	1	0 1
C10	CAP.FXD PAPER	323-001-034 SAME AS 9462C8	07421	REF	
C11.C12	CAP.FXD CERAMIC 0.02MFD.50VDCW	55C21	56289	2	0 2
C13	CAP.FXD PAPER	323-001-034 SAME AS 9462C8	07421	REF	
C14	CAP.FXD ELECT. TANTALUM TYPE 35 MFD 15 VDCW	322-003-154 111D356X0015J1	07421 56289	1	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
C15	CAP.FXD ELECT	322-004-201	07421	R 1	
		SAME AS 9453C2			
CR1	SEMICONDUCTOR	343-212-001	07421	4	5
	PIV 30V, 250 MA	343-001 OR 343-005	07421		10
CR2	SEMICONDUCTOR	1N629	73293	1	2
					4
CR3-CR5	SEMICONDUCTOR	343-212-001	07421	REF	
		SAME AS 9462CR1			
CR6,CR7	SEMICONDUCTOR	1N99	73293	R 2	
		SAME AS 9460CR3			
Q1,Q2	TRANSISTOR	345-212-003	07421	2	3
		0173020	07421		6
Q3,Q4	TRANSISTOR	345-221-001	07421	2	2
		2N859	56289		4
Q5	TRANSISTOR	345-111-004	07421	1	2
		345-004	07421		4
Q6	TRANSISTOR	345-121-005	07421	1	2
		345-005	07421		4
Q7	TRANSISTOR	345-221-003	07421	2	2
		2N2164	56289		4
Q8	TRANSISTOR	345-121-001	07421	R 1	
		SAME AS 9453Q1			
Q9-Q10	TRANSISTOR	345-121-002	07421	4	6
		345-002	07421		12
Q11	TRANSISTOR	345-221-003	07421	REF	
		SAME AS 9462Q7			
Q12,Q13	TRANSISTOR	345-121-002	07421	REF	
		SAME AS 9462Q9			
R1	RES,FXD COMP	RC07GF223J	44655	R 3	
		SAME AS 9453R37			

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R2	RES,FXD COMP 499,000 OHMS 1% 1/8 WATT	312-001-405 MEA/TO-4993F	07421 07716	5	0 1
R3	RES,FXD COMP	RC07GF391J SAME AS 9453R26	44655	R 1	
R4-R6	RES,FXD FILM	312-001-405 SAME AS 9462R2	07421	REF	
R7	RES,FXD FILM	312-001-242 SAME AS 9461R4	07421	R 2	
R8,R9	RES,FXD FILM 15,400 OHMS 1% 1/8 WATT	312-001-260 MEA/TO-1542F	07421 07716	3	0 1
R10	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	R 2	
R11	RES,FXD FILM 48,700 OHMS 1% 1/8 WATT	312-001-308 MEA/TO-4872F	07421 07716	1	0 1
R12	RES,FXD FILM 1210 OHMS 1% 1/8 WATT	312-001-154 MEA/TO-1211F	07421 07716	1	0 1
R13	RES,FXD FILM	312-001-242 SAME AS 9461R4	07421	REF	
R14	RES,FXD FILM	312-001-260 SAME AS 9462R8	07421	REF	
R15	RES,FXD COMP	RC20GF271J SAME AS 9453R23	44655	R 2	
R16,R17	RES,FXD COMP 33 OHMS 5% 1/2 WATT	RC20GF330J	44655	2	0 1
R18	RES,FXD COMP	RC20GF271J SAME AS 9453R23	44655	REF	
R19	RES,FXD COMP 15,000 OHMS 5% 1/4 WATT	RC07GF153J	44655	2	0 2
R20	RES,FXD COMP 10 OHMS 5% 1/4 WATTS	RC07GF100J	44655	1	0 1
R21	RES,FXD COMP	RC07GF303J SAME AS 9453R7	44655	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R22	RES,FXD COMP	RC07GF223J SAME AS 9453R37	44655	REF	
R23	RES,FXD COMP	RC07GF154J SAME AS 9453R9	44655	R 1	
R24	RES,FXD WIRE 10 OHMS 5% 3WATTS	313-001-008 242E1005	07421 56289	1	0 1
R25	RES,FXD COMP	RC07GF203J SAME AS 9453R16	44655	R 1	
R26	RES,ADJ WIRE 50,000 OHMS 10% 1 WATT	315-004-013 260P1-503	07421 80294	1	1 1
R27	RES,FXD COMP	RC07GF393J SAME AS 9453R27	44655	R 2	
R28	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	REF	
R29	RES,FXD COMP	RC07GF153J SAME AS 9462R19	44655	REF	
R30	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	R 2	
R31	RES,FXD COMP	RC07GF393J SAME AS 9453R27	44655	REF	
R32	RES,FXD COMP 3,300 OHMS 5% 1/2 WATT	RC20GF332J	44655	1	0 1
R34	RES,FXD COMP	RC07GF512J SAME AS 9453R42	44655	R 1	
R35	RES,FXD FILM	312-001-405 SAME AS 9462R2	07421	REF	
R36	RES,FXD COMP	RC07GF223J SAME AS 9453R37	44655	REF	
R37	RES,FXD COMP	RC07GF562J SAME AS 9453R2	44655	R 1	
R38	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	R 2	
R39	RES,FXD COMP	RC07GF821J SAME AS 9453R18	44655	R 1	
R40	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R41	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R42	RES,FXD COMP 47,000 OHMS 5% 1/4 WATT	RC07GF473J	44655	2	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R43	RES,FXD COMP	RC07GF104J	44655	R 2	
		SAME AS 9453R3			
R44	RES,FXD COMP	RC07GF473J	44655	REF	
		SAME AS 9462R44			
R45	RES,FXD COMP	RC07GF104J	44655	REF	
		SAME AS 9453R3			
R46	RES,ADJ WIRE	315-004-010	07421	R 1	
		SAME AS 9460R1			
TP1,2	TEST PROBE	377-001-010	07421	2	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9463-501	MODULE ASSEMBLY	9463000-501	07421	1	0 1
TB1	COMPONENT BOARD	9463400	07421	1	
C1	CAP.FXD MICA	321-001-044 SAME AS 9460C5	07421	R 1	
C2		*SELECTED		1	
C3	CAP.FXD MICA 10 MMF 10% 500VDCW	321-001-005 DM15-100J	07421 84171	2	0 1
C4	CAP.FXD MICA 390 MMF 5% 500VDCW	321-001-042 DM15-391J	07421 84171	1	0 1
C5	CAP.FXD MICA 24 MMF5% 500VDCW	321-001-011 DM15-240J	07421 84171	1	0 1
C6	CAP.FXD MICA 910 MMF 5% 300 VDCW	321-001-052 DM15-911J	07421 84171	3	0 3
C7		*SELECTED		1	
C8	CAP.FXD MICA	321-001-052 SAME AS 94631C6	07421	REF	
C9	CAP.FXD CERAMIC 5000 MMF 50VDCW DISK TYPE	TG-D50	56289	1	0 2
C10	CAP.FXD MICA	321-001-052 SAME AS 94631C6	07421	REF	
C11	CAP.FXD MICA	321-001-005 SAME AS 94631C3	07421	REF	
C12,C13	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	R 5	
C14	CAP.FXD ELECT TANTALUM TYPE 1 MFD 20 VDCW	150D105X0020A2	56289	1	0 2
C15	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C16	CAP.FXD MICA 30 MMF5% 500VDCW	321-001-013 DM15-300J	07421 84171	2	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
C17	CAP.FXD MICA 39 MMF5% 500VDCW	321-001-016 DM15-390J 6	07421 84171	2	0 1
C18	CAP.FXD MICA 3 MMF 20% 500VDCW	321-001-003 DM15-030M	07421 84171	1	0 1
C19	CAP.FXD MICA	321-001-016 SAME AS 94631C17	07421	REF	
C20	CAP.FXD MICA	321-001-013 SAME AS 94631C16	07421	REF	
C21	CAP.FXD PAPER	323-001-034 SAME AS 9462C8	07421	R 4	
C22	CAP.FXD MICA	321-001-031 SAME AS 9461C24	07421	R 1	
C23-C25	CAP.FXD PAPER	323-001-034 SAME AS 9462C8	07421	REF	
C26,C27	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C28	CAP FXD ELECT TANTALUM TYPE 33 MFD 10 VDCW	150D336X0010B2	56289	1	0 1
C29		*SELECTED		1	
C30		*SELECTED		1	
L1	INDUCTOR	SD96A	05375	1	1 1
L2	COIL	1537-42	99800	1	0 1
L3	COIL	1537-26	99800	2	0 1
L4	COIL	1537-38	99800	1	0 1
L5	COIL	1537-26 SAME AS 94631L3	99800	REF	
L6	COIL	1537-60	99800	1	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
L7	COIL	1537-52	99800	1	0 1
Q1	TRANSISTOR	2N1742	46859	1	2 4
Q2	TRANSISTOR	2N706	04713	8	3 6
Q3	TRANSISTOR	2N1743	46859	2	2 4
Q4	TRANSISTOR	2N1225	02735	2	2 4
Q5-Q7	TRANSISTOR	2N708 SAME AS 9463102	04713	REF	
R1	RES,FXD COMP	RC07GF331J SAME AS 9453R36	44655	R 3	
R2	RES,FXD COMP 180 OHMS 5% 1/4 WATT	RC07GF181J	44655	1	0 1
R3	RES,FXD COMP	RC07GF152J SAME AS 9453R34	44655	R 1	
R4	RES,FXD COMP	RC07GF153J SAME AS 9462R19	44655	R 2	
R5	RES,FXD COMP	RC07GF472J SAME AS 9453R43	44655	R 3	
R6	RES,FXD COMP 13,000 OHMS 5% 1/4 WATT	RC07GF133J	44655	1	0 1
R7	RES,FXD COMP	RC07GF472J SAME AS 9453R43	44655	REF	
R8	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	R 11	
R9	RES,FXD COMP 470 OHMS 5% 1/4 WATT	RC07GF471J	44655	4	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R10	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	REF	
R11	RES,FXD COMP	RC07GF471J SAME AS 94631R9	44655	REF	
R12	RES,FXD COMP	RC07GF123J SAME AS 9453R4	44655	R 3	
R13	RES,FXD COMP	RC07GF562J SAME AS 9453R2	44655	R 2	
R14	RES,FXD COMP 56,000 OHMS 5% 1/4 WATT	RC07GF563J	44655	2	01
R15	RES,FXD COMP	RC07GF202J SAME AS 9453R39	44655	R 4	
R16	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	R 12	
R17	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	REF	
R18	RES,FXD COMP	RC07GF203J SAME AS 9453R16	44655	R 2	
R19	RES,FXD COMP	RC07GF333J SAME AS 9460R23	44655	R 2	
R20	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	REF	
R21	RES,FXD COMP	RC07GF471J SAME AS 94631R9	44655	REF	
R22	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R23	RES,FXD COMP	RC07GF331J SAME AS 9453R36	44655	REF	
R24	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	R 4	
R25	RES,FXD COMP	RC07GF512J SAME AS 9453R42	44655	R 2	
R26	RES,FXD COMP 91 OHMS 5% 1/4 WATT	RC07GF910J	44655	2	01
R27	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R28	RES,FXD COMP	RC07GF202J SAME AS 9453R39	44655	REF	
R29	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	REF	
R30	RES,FXD COMP 6,200 OHMS 5% 1/4 WATT	RC07GF622J	44655	1	02

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R31	RES•FXD COMP	RC07GF303J	44655	R 1	
		SAME AS 9453R7			
R32	RES•FXD COMP	RC07GF101J	44655	REF	
		SAME AS 9453R6			
R33	RES•FXD COMP	RC07GF102J	44655	REF	
		SAME AS 9453R32			
R34	RES•FXD COMP	RC07GF101J	44655	REF	
		SAME AS 9453R6			
R35	RES•FXD COMP	RC20GF331J	44655	2	0
	330 OHMS 5%				1
	1/2 WATT				
R36	RES•FXD COMP	*SELECTED	44655	1	
T1	TRANSFORMER	9468140-506	07421	1	1
					1
TB2	COMPONENT BOARD	9463500	07421	1	
C1	CAP•FXD PAPER	323-001-013	07421	R 1	
		SAME AS 9453C3			
C2	CAP•FXD MICA	321-001-027	07421	1	0
	100 MMF 5%	DM15-101J	84171		1
	500VDCW				
C3	CAP•FXD ELECT	150D105X0020A2	56289	R 4	
		SAME AS 94631C14			
C4•C5	CAP•FXD ELECT	150D105X0010A2	56289	2	0
	TANTALUM TYPE				1
	1 MFD 10 VDCW				
C6	CAP•FXD ELECT	150D105X0020A2	56289	REF	
		SAME AS 94631C14			
C7	CAP•FXD MICA	321-001-039	07421	2	0
	300 MMF 5%	DM15-301J	84171		1
	500VDCW				
C8	CAP•FXD MICA	321-001-042	07421	R 2	
		SAME AS 94631C4			
C9	CAP•FXD MICA	321-001-013	07421	R 1	
		SAME AS 94631C16			
C10	CAP•FXD MICA	321-001-042	07421	REF	
		SAME AS 94631C4			
C11	CAP•FXD MICA	321-001-039	07421	REF	
		SAME AS 94631C7			
C12-C14	CAP•FXD ELECT	150D475X0015B2	56289	3	0
	TANTALUM TYPE				1
	4.7 MFD 15 VDCW				

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
C15,C16	CAP.FXD ELECT	150D105X0020A2 SAME AS 94631C14	56289	REF	
C17	CAP.FXD ELECT TANTALUM TYPE 100 MFD 15 VDCW	150D107X0015S2	56289	1	0 1
C18,C19	CAP.FXD CERAMIC 5,000MMF+80-20% 1/VV- T	DM502	71590	2	0 1
C20	CAP.FXD MICA 15 MMF 5% 500VDCW	321-001-007 DM15-150J	07421 84171	1	0 1
C21,C22	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	R 2	
C23-C26	CAP.FXD ELECT TANTALUM TYPE 47 MFD 20 VDCW	322-001-212 150D476X9020R2	07421 56289	4	0 1
C27	CAP.FXD ELECT TANTALUM TYPE 100 MFD 20 VDCW	150D107X0020S2	56289	1	0 1
L1	COIL	1537-56	99800	2	0 1
L2	COIL	1537-80	99800	1	0 1
L3	COIL	1537-56 SAME AS 94631L1	99800	REF	
Q1	TRANSISTOR	2N1743 SAME AS 94631Q3	46859	REF	
Q2	TRANSISTOR	2N1225 SAME AS 94631Q4	02735	REF	
Q3-Q5	TRANSISTOR	2N708 SAME AS 94631Q2	04713	REF	
Q6	TRANSISTOR	345-122-001 2N598	07421 11711	1	2 4
Q7,Q8	TRANSISTOR	345-121-001 SAME AS 9453Q1	07421	R 2	

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Q9	TRANSISTOR	2N708 SAME AS 94631Q2	04713	REF	
R1	RES,FXD COMP	RC07GF123J SAME AS 9453R4	44655	REF	
R2	RES,FXD COMP	RC07GF273J SAME AS 9453R12	44655	R 1	
R3	RES,FXD COMP	RC07GF562J SAME AS 9453R2	44655	REF	
R4	RES,FXD COMP	RC07GF563J SAME AS 94632R14	44655	REF	
R5	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	REF	
R6	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R7	RES,FXD COMP	RC07GF202J SAME AS 9453R39	44655	REF	
R8	RES,FXD COMP	RC07GF203J SAME AS 9453R16	44655	REF	
R9	RES,FXD COMP	RC07GF333J SAME AS 9460R23	44655	REF	
R10	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	REF	
R11	RES,FXD COMP	RC07GF471J SAME AS 94631R9	44655	REF	
R12	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R13	RES,FXD COMP	RC07GF331J SAME AS 9453R36	44655	REF	
R14	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R15	RES,FXD COMP	RC07GF512J SAME AS 9453R42	44655	REF	
R16	RES,FXD COMP	RC07GF202J SAME AS 9453R39	44655	REF	
R17	RES,FXD COMP	RC07GF910J SAME AS 94631R26	44655	REF	
R18	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R19	RES,FXD COMP 9,100 OHMS 5% 1/4 WATT	RC07GF912J	44655	1	0 1
R20	RES,FXD COMP	RC07GF223J SAME AS 9453R37	44655	R 1	
R21	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	REF	

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R22	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R23	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	REF	
R24	RES,FXD COMP	RC20GF331J SAME AS 94631R35	44655	REF	
R25	RES,FXD COMP	RC07GF392J SAME AS 94631R25	44655	R 1	
R26	RES,FXD COMP	RC07GF682J SAME AS 9453R9	44655	R 1	
R27	RES,FXD COMP	RC07GF153J SAME AS 9462R19	44655	REF	
R28	RES,FXD COMP 510 OHMS 5% 1/4 WATT	RC07GF511J	44655	1	07
R29	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R30	RES,FXD COMP 3,600 OHMS 5% 1/4 WATT	RC07GF362J	44655	2	01
R31	RES,FXD COMP	RC07GF123J SAME AS 9453R4	44655	REF	
R32	RES,FXD COMP	RC07GF513J SAME AS 9453R5	44655	R 1	
R33	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R34	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R35	RES,FXD COMP	RC07GF362J SAME AS 94631R30	44655	REF	
R36	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R37	RES,FXD COMP	RC07GF472J SAME AS 9453R43	44655	REF	
R38	RES,FXD COMP 750 OHMS 5% 1/4 WATT	RC07GF751J	44655	1	01
R39	RES,FXD COMP 47 OHMS 5% 1/4 WATT	RC07GF470J	44655	1	01
R40	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R41	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
X1	FILTER	9463120	07421	1	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9464	MODULE ASSEMBLY	9464000	07421	1	0 1
C1	CAP.FXD CERAMIC	55C21 SAME AS 9462C11	56289	R 2	
C2	CAP.FXD PAPER	323-001-042 SAME AS 9453	07421	R 2	
C3	CAP.FXD MICA 160 MMF 5% 500VDCW	321-001-032 DM15-161J	07421 84171	2	0 1
C4	CAP.FXD CERAMIC	55C21 SAME AS 9462C11	56289	REF	
C5	CAP.FXD PAPER	323-001-042 SAME AS 9453	07421	REF	
C6	CAP.FXD MICA	321-001-040 SAME AS 9453C5	07421	R 1	
C7	CAP.FXD MICA	321-001-032 SAME AS 9464C3	07421	REF	
CR1,CR2	SEMICONDUCTOR	343-212-001 SAME AS 9462CR1	07421	R 4	
CR3,CR4	SEMICONDUCTOR PIV 25V, 50 MA	343-111-003 343-003	07421 07421	4	4 8
CR5,CR6	SEMICONDUCTOR	343-212-001 SAME AS 9462CR1	07421	REF	
CR7,CR8	SEMICONDUCTOR	343-111-003 SAME AS 9464CR3	07421	REF	
Q1	TRANSISTOR	345-212-003 SAME AS 9462Q1	07421	R 2	
Q2,Q3	TRANSISTOR	345-121-002 SAME AS 9462Q9	07421	R 6	
Q4	TRANSISTOR	345-111-001 345-001	07421 07421	2	3 6
Q5	TRANSISTOR	345-121-002 SAME AS 9462Q9	07421	REF	
Q6	TRANSISTOR	345-121-005 SAME AS 9462Q6	07421	R 2	
Q7	TRANSISTOR	345-111-004 SAME AS 9462Q5	07421	R 2	
Q8	TRANSISTOR	345-212-003 SAME AS 9462Q1	07421	REF	

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Q9,Q10	TRANSISTOR	345-121-002 SAME AS 9462Q9	07421	REF	
Q11	TRANSISTOR	345-111-001 SAME AS 9464Q4	07421	REF	
Q12	TRANSISTOR	345-121-002 SAME AS 9462Q9	07421	REF	
Q13	TRANSISTOR	345-121-005 SAME AS 9462Q6	07421	REF	
Q14	TRANSISTOR	345-111-004 SAME AS 9462Q5	07421	REF	
R1	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	R 4	
R2	RES,ADJ WIRE	315-004-010 SAME AS 9460R1	07421	R 2	
R3	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R4	RES,FXD FILM 61900 OHMS 1% 1/8 WATT	312-001-318 MEA/TO-6192F	07421 07716	2	0 1
R5	RES,FXD COMP	RC07GF104J SAME AS 9453R3	44655	R 2	
R6	RES,FXD COMP	RC07GF153J SAME AS 9462R19	44655	R 2	
R8,R9	RES,FXD COMP 20,000 OHMS 5% 1/2 WATT	RC20GF203J	44655	4	0 2
R10	RES,FXD COMP	RC07GF622J SAME AS 94631R30	44655	R 2	
R11	RES,FXD COMP 300 OHMS 5% 1/4 WATT	RC07GF301J	44655	2	0 1
R12	RES,FXD COMP	RC07GF513J SAME AS 9453R5	44655	R 2	
R13	RES,FXD COMP 2,400 OHMS 5% 1/4 WATT	RC07GF242J	44655	2	0 1
R14	RES,FXD COMP	RC07GF333J SAME AS 9460R23	44655	R 2	
R15,R17	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	R 8	
R18,R19	RES,FXD COMP	RC07GF510J SAME AS 9453R21	44655	R 4	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R20	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	REF	
R21	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R22	RES,ADJ WIRE	315-004-010 SAME AS 9460R1	07421	REF	
R23	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R24	RES,FXD FILM	312-001-318 SAME AS 9464R4	07421	REF	
R25	RES,FXD COMP	RC07GF104J SAME AS 9453R3	44655	REF	
R26	RES,FXD COMP	RC07GF153J SAME AS 9462R19	44655	REF	
R28	RES,FXD COMP 8.2MEG OHMS 5% 1/2 WATT	RC20GF825J	44655	1	0 1
R29,R30	RES,FXD COMP	RC20GF203J SAME AS 9464R8	44655	REF	
R31	RES,FXD COMP	RC07GF622J SAME AS 94631R30	44655	REF	
R32	RES,FXD COMP	RC07GF301J SAME AS 9464R11	44655	REF	
R33	RES,FXD COMP	RC07GF513J SAME AS 9453R5	44655	REF	
R34	RES,FXD COMP	RC07GF242J SAME AS 9464R13	44655	REF	
R35	RES,FXD COMP	RC07GF333J SAME AS 9460R23	44655	REF	
R36-R38	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	REF	
R39,R40	RES,FXD COMP	RC07GF510J SAME AS 9453R21	44655	REF	
R41	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	REF	

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9465	MODULE ASSEMBLY	9465000	07421	R 1	
C1,C2	CAP.FXD ELECT	322-004-201 SAME AS 9453C2	07421	R 4	
C3	CAP.FXD MICA 22 MMF 5% 500 VDCW	321-001-010 DM15-220J	07421 84171	2	0 1
C4,C5	CAP.FXD ELECT	322-004-201 SAME AS 9453C2	07421	REF	
C6	CAP.FXD MICA	321-001-010 SAME AS 9465C3	07421	REF	
C7	CAP.FXD ELECT TANTALUM TYPE 6.8 MFD 35 VDCW	322-001-339 150D685X9035B2	07421 56289	2	0 1
C8	CAP.FXD MICA 510 MMF 5% 300 VDCW	321-001-046 DM15-511J	07421 84171	1	0 1
C9	CAP.FXD MICA	321-001-052 SAME AS 94631C6	07421	R 1	
C10	CAP.FXD ELECT	322-001-339 SAME AS 9465C7	07421	REF	
CR1-CR3	SEMICONDUCTOR	343-212-001 SAME AS 9462CR1	07421	R 6	
CR4	SEMICONDUCTOR	343-111-003 SAME AS 9464CR3	07421	R 2	
CR5-CR7	SEMICONDUCTOR	343-212-001 SAME AS 9462CR1	07421	REF	
CR8	SEMICONDUCTOR	343-111-003 SAME AS 9464CR3	07421	REF	
L1-L4	CHOKE,RF	2500-32 SAME AS 9460L3	99800	R 4	
Q1,Q2	TRANSISTOR	345-212-003 SAME AS 9462Q1	07421	R 4	
Q3	TRANSISTOR	345-121-002 SAME AS 9462Q9	07421	R 2	
Q4	TRANSISTOR	345-111-001 SAME AS 9464Q4	07421	R 2	
Q5	TRANSISTOR	345-111-004 SAME AS 9462Q5	07421	R 2	
Q6	TRANSISTOR	345-121-005 SAME AS 9462Q6	07421	R 2	
Q7,Q8	TRANSISTOR	345-212-003 SAME AS 9462Q1	07421	REF	
Q9	TRANSISTOR	345-121-002 SAME AS 9462Q9	07421	REF	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
Q10	TRANSISTOR	345-111-001 SAME AS 9464Q4	07421	REF	
Q11	TRANSISTOR	345-111-004 SAME AS 9462Q5	07421	REF	
Q12	TRANSISTOR	345-121-005 SAME AS 9462Q6	07421	REF	
R1	RES,FXD COMP	RC07GF202J SAME AS 9453R39	44655	R 2	
R2	RES,FXD COMP	RC07GF682J SAME AS 9453R9	44655	R 6	
R3	RES,FXD COMP 111,000 OHMS 5% 1/4 WATT	RC07GF114J	44655	4	0 1
R4	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	R 4	
R5	RES,VAR WIRE 10,000 OHMS	275P1-103	80294	2	1 1
R6	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R7	RES,FXD COMP	RC07GF114J SAME AS 9465R3	44655	REF	
R8	RES,FXD COMP	RC07GF394J SAME AS 9453R8	44655	R 2	
R9	RES,FXD COMP	RC07GF563J SAME AS 94632R14	44655	R 2	
R10	RES,FXD COMP	RC07GF682J SAME AS 9453R9	44655	REF	
R11	RES,FXD COMP	RC07GF183J SAME AS 9453R15	44655	R 2	
R12	RES,FXD COMP 510,000 OHMS 5% 1/4 WATT	RC07GF514J	44655	2	0 1
R13	RES,FXD COMP	RC07GF223J SAME AS 9453R37	44655	R 2	
R14	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	R 2	
R15	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	R 6	
R16	RES,FXD COMP	RC07GF682J SAME AS 9453R9	44655	REF	
R17	RES,FXD COMP	RC07GF363J SAME AS 9453R28	44655	R 2	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R18	RES,FXD COMP 270 OHMS 5% 1/4 WATT	RC07GF271J	44655	2	0 1
R19	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	REF	
R20,R21	RES,FXD COMP	RC07GF510J SAME AS 9453R21	44655	R 4	
R22	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	REF	
R23	RES,FXD COMP	RC07GF202J SAME AS 9453R39	44655	REF	
R24	RES,FXD COMP	RC07GF682J SAME AS 9453R9	44655	REF	
R25	RES,FXD COMP	RC07GF114J SAME AS 9465R3	44655	REF	
R26	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R27	RES,VAR WIRE	275P1-103 SAME AS 9465R5	80294	REF	
R28	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R29	RES,FXD COMP	RC07GF114J SAME AS 9465R3	44655	REF	
R30	RES,FXD COMP	RC07GF394J SAME AS 9453R8	44655	REF	
R31	RES,FXD COMP	RC07GF563J SAME AS 94632R14	44655	REF	
R32	RES,FXD COMP	RC07GF682J SAME AS 9453R9	44655	REF	
R33	RES,FXD COMP	RC07GF183J SAME AS 9453R15	44655	REF	
R34	RES,FXD COMP	RC07GF514J SAME AS 9465R12	44655	REF	
R35	RES,FXD COMP	RC07GF223J SAME AS 9453R37	44655	REF	
R36	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	REF	
R37	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	REF	
R38	RES,FXD COMP	RC07GF682J SAME AS 9453R9	44655	REF	
R39	RES,FXD COMP	RC07GF363J SAME AS 9453R28	44655	REF	
R40	RES,FXD COMP	RC07GF271J SAME AS 9465R18	44655	REF	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R41	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	REF	
R42,R43	RES,FXD COMP	RC07GF510J SAME AS 9453R21	44655	REF	
R44	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	REF	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9466	MODULE ASSEMBLY	9466000	07421	1	0 1
C1	CAP.FXD MICA 360 MMF 5% 500VDCW	321-001-041 DM15-361J	07421 84171	1	0 1
C2	CAPKFXD CERAMIC	TG-D50 SAME AS 94631C9	56289	R 3	
C4	CAP.FXD CERAMIC	TG-D50 SAME AS 94631C9	56289	REF	
C5	CAP.FXD MICA	321-001-031 SAME AS 9461C24	07421	R 1	
C6	CAP.FXD CERAMIC	TG-D50 SAME AS 94631C9	56289	REF	
C7,C8	CAP.FXD CERAMIC 0.1MFD,20VDCW	5C7	56289	2	0 1
L1	COIL	9468140-503	07421	1	1 1
L2	COIL	9468140-504	07421	1	1 1
Q1	TRANSISTOR	2N708 SAME AS 9463IQ2	04713	R 1	
Q2	TRANSISTOR	2N1225 SAME AS 94631Q4	02735	R 1	
Q3	TRANSISTOR	345-121-001 SAME AS 9453Q1	07421	R 1	
R1	RES,FXD COMP	RC07GF472J SAME AS 9453R43	44655	R 1	
R2	RES,FXD COMP	RC07GF152J SAME AS 9453R34	44655	R 1	
R3	RES,FXD COMP	RC07GF202J SAME AS 9453R39	44655	R 1	
R4	RES,FXD COMP	RC07GF271J SAME AS 9465R18	44655	R 1	
R5	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	R 1	
R7	RES,FXD COMP 3,300 OHMS 5% 1/4 WATT	RC07GF332J	44655	1	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R8	RES,ADJ WIRE 2,000 OHMS	300P1-202	80294	1	1 1
R9	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	R 1	
R10	RES,FXD COMP	RC07GF393J SAME AS 9453R27	44655	R 1	
R11	RES,FXD COMP	RC07GF223J SAME AS 9453R37	44655	R 1	
R12	RES,FXD COMP	RC07GF151J SAME AS 9453R5	44655	R 1	
R13	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	R 1	
X1	DIVIDER ASSY	9466700-501	07421	1	
X2	DIVIDER ASSY	9466700	07421	1	
X3	DIVIDER ASSY	9466700-502	07421	1	
X4	DIVIDER ASSY	9466700-500	07421	1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9467	MODULE ASSEMBLY	9467000	07421	1	0 1
C1	CAP.VAR AIR	DS443 SAME AS 9460C2	73899	R 1	
C2	CAP.FXD MICA 500 MMF 5% 300 VDCW	321-001-045 DM15-501J	07421 84171	1	0 1
C4	CAP.FXD PAPER	323-001-225 SAME AS 9462C4	07421	R 2	
C5		*SELECTED		1	
C6	CAP.FXD PAPER	323-001-225 SAME AS 9462C4	07421	REF	
C7	CAP.FXD MICA	321-001-053 SAME AS 9453C4	07421	R 1	
C8	CAP.FXD MICA 250 MMF 5% 500VDCW	321-001-037 DM15-251J	07421 84171	1	0 1
C9	CAP.FXD CERAMIC	55C21 SAME AS 9462C11	56289	R 1	
C10	CAP.FXD PAPER	323-001-042 SAME AS 9453	07421	R 1	
C11	CAP.FXD MICA	321-001-032 SAME AS 9464C3	07421	R 1	
CR1,CR2	PAIR SEMICONDUCTOR	9461120 SAME AS 9461CR1	07421	R 1	
CR3-CR6	SEMICONDUCTOR	343-212-001 SAME AS 9462CR1	07421	R 4	
CR7-CR11	SEMICONDUCTOR	343-111-003 SAME AS 9464CR3	07421	R 5	
L1	CHOKE	4649	76493	1	0 1
Q1	TRANSISTOR	2N1225 SAME AS 9463Q4	02735	R 1	
Q2	TRANSISTOR	345-212-003 SAME AS 9462Q1	07421	R 1	
Q3,Q4	TRANSISTOR	345-121-002 SAME AS 9462Q9	07421	R 4	
Q5	TRANSISTOR	345-111-001 SAME AS 9464Q4	07421	R 3	
Q6	TRANSISTOR	345-121-002 SAME AS 9462Q9	07421	REF	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
Q7	TRANSISTOR	345-121-005 SAME AS 9462Q6	07421	R 1	
Q8	TRANSISTOR	345-111-004 SAME AS 9462Q5	07421	R 1	
Q9	TRANSISTOR	345-121-002 SAME AS 9462Q9	07421	REF	
Q10,Q11	TRANSISTOR	345-111-001 SAME AS 9464Q4	07421	REF	
Q12	TRANSISTOR	345-121-001 SAME AS 9453Q1	07421	R 1	
R1	RES,ADJ WIRE	315-004-010 SAME AS 9460R1	07421	R 2	
R2	RES,FXD COMP	RC07GF302J SAME AS 9453R9	44655	R 1	
R3	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	R 3	
R4	RES,FXD COMP	RC07GF822J SAME AS 9453R11	44655	R 1	
R5	RES,VAR COMP	AS3601 SAME AS 9460R6	44655	R 1	
R6,R7	RES,FXD FILM	312-001-175 SAME AS 9460R7	07421	R 2	
R8	RES,FXD COMP	RC07GF752J SAME AS 9461R6	44655	R 1	
R9	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R10	RES,ADJ WIRE	315-004-010 SAME AS 9460R1	07421	REF	
R11	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R12	RES,FXD COMP	RC07GF623J SAME AS 9460R31	44655	R 2	
R13	RES,FXD COMP	RC07GF203J SAME AS 9453R16	44655	R 1	
R14	RES,FXD COMP	RC07GF394J SAME AS 9453R8	44655	R 1	
R15	RES,FXD COMP	RC07GF104J SAME AS 9453R3	44655	R 2	
R16	RES,FXD FILM	312-001-318 SAME AS 9464R4	07421	R 1	
R17	RES,FXD COMP	RC07GF101J SAME AS 9453R6	44655	R 1	
R18	RES,FXD COMP	RC07GF623J SAME AS 9460R31	44655	REF	
R19	RES,FXD COMP 8.2K MEG OHMS 5% 1/4 WATT	RC07GF825J	44655	1	0 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R20	RES,FXD COMP 1,000 OHMS 5% 1/2 WATT	RC20GF153J	44655	1	0 1
R21,R22	RES,FXD COMP	RC20GF203J SAME AS 9464R8	44655	R 2	
R23	RES,FXD COMP	RC07GF622J SAME AS 94631R30	44655	R 1	
R24	RES,FXD COMP	RC07GF301J SAME AS 9464R11	44655	R 1	
R25	RES,FXD COMP	RC07GF513J SAME AS 9453R5	44655	R 1	
R26	RES,FXD COMP	RC07GF242J SAME AS 9464R13	44655	R 1	
R27	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	R 4	
R28	RES,FXD COMP	RC07GF333J SAME AS 9460R23	44655	R 1	
R29,R30	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	REF	
R31,R32	RES,FXD COMP	RC07GF510J SAME AS 9453R21	44655	R 2	
R33	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	REF	
R34,R35	RES,FXD COMP	RC07GF332J SAME AS 9466R7	44655	R 2	
R36	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	R 1	
R37	RES,FXD COMP	RC07GF104J SAME AS 9453R3	44655	REF	
R38	RES,FXD COMP	RC07GF202J SAME AS 9453R39	44655	R 1	
R39	RES,FXD COMP 4,300 OHMS 5% 1/4 WATT	RC07GF432J	44655	1	0 1
R40-R42	RES,FXD COMP	RC07GF303J SAME AS 9453R7	44655	R 3	
R46	RES,FXD COMP 160,000 OHMS 5% 1/4 WATT	RC07GF164J	44655	1	0 1
T1	TRANSFORMER	9460120-2 SAME AS 9460T4	07421	R 1	
T2	TRANSFORMER	58-123-09 SAME AS 9460T1	80483	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
TP1	TEST PROBE	377-011-010	07421	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9468	MODULE ASSEMBLY	9468000	07421	R 1	
C1	CAP.FXD MICA	321-001-052	07421	R 5	
		SAME AS 94631C6			
C2	CAP.FXD MICA	321-001-044	07421	R 2	
		SAME AS 9460C5			
C3	CAP.FXD MICA	321-001-052	07421	REF	
		SAME AS 94631C6			
C4	CAP.FXD MICA	321-001-008	07421	2	0
	18 MMF 5%	DM15-180J	84171		1
	500VDCW				
C5-C7	CAP.FXD MICA	321-001-052	07421	REF	
		SAME AS 94631C6			
C8	CAP.FXD MICA	321-001-044	07421	REF	
		SAME AS 9460C5			
C9	CAP.FXD MICA	321-001-008	07421	REF	
		SAME AS 9468C4			
CR1	CRYSTAL	9468120	07421	1	1
					2
Q1-Q3	TRANSISTOR	2N1742	46859	R 3	
		SAME AS 9463IQ1			
R1	RES,FXD COMP	RC07GF752J	44655	R 1	
		SAME AS 9461R6			
R2	RES,FXD COMP	RC07GF472J	44655	R 2	
		SAME AS 9453R43			
R3	RES,FXD COMP	RC07GF222J	44655	R 1	
		SAME AS 9461R30			
R4	RES,FXD COMP	RC07GF153J	44655	R 1	
		SAME AS 9462R19			
R5	RES,FXD COMP	RC07GF510J	44655	R 1	
		SAME AS 9453R21			
R6	RES,FXD COMP	RC07GF472J	44655	REF	
		SAME AS 9453R43			
R7	RES,FXD COMP	RC07GF102J	44655	R 3	
		SAME AS 9453R32			
R8	RES,FXD COMP	RC07GF331J	44655	R 2	
		SAME AS 9453R36			
R9	RES,FXD COMP	RC07GF102J	44655	REF	
		SAME AS 9453R32			
R10	RES,FXD COMP	RC07GF331J	44655	REF	
		SAME AS 9453R36			
R12	RES,FXD COMP	RC07GF102J	44655	REF	
		SAME AS 9453R32			
T1	TRANSFORMER	9468140	07421	1	1
					1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
T2	TRANSFORMER	9468100-500	07421	1	1 1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
9469	MODULE ASSEMBLY	9469000	07421	R 1	
C1	CAP,FXD PLASTIC	55C21 SAME AS 9462C11	56289	R 1	
C2	CAP,FXD PAPER	323-001-042 SAME AS 9453	07421	R 1	
C3	CAP,FXD MICA	321-001-037 SAME AS 9467C8	07421	R 1	
C4	CAP,FXD MICA	321-001-032 SAME AS 9464C3	07421	R 1	
CR1,CR2	SEMICONDUCTOR	343-212-001 SAME AS 9462CR1	07421	R 2	
CR3,CR4	SEMICONDUCTOR	343-111-003 SAME AS 9464CR3	07421	R 2	
Q1	TRANSISTOR	343-212-003 SAME AS 9462Q1	07421	R 1	
Q2,Q3	TRANSISTOR	345-121-002 SAME AS 9462Q9	07421	R 3	
Q4	TRANSISTOR	345-111-001 SAME AS 9464Q4	07421	R 1	
Q5	TRANSISTOR	345-121-002 SAME AS 9462Q9	07421	REF	
Q6	TRANSISTOR	345-121-005 SAME AS 9462Q6	07421	R 1	
Q7	TRANSISTOR	345-111-004 SAME AS 9462Q5	07421	R 1	
R1	RES,FXD COMP	RC07GF102J SAME AS 9453R32	44655	R 1	
R2	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	R 2	
R3	RES,FXD FILM	315-004-013 SAME AS 9462R26	07421	R 1	
R4	RES,FXD COMP	RC07GF103J SAME AS 9453R11	44655	REF	
R5	RES,FXD COMP	RC07GF104J SAME AS 9453R3	44655	R 1	
R6	RES,FXD	312-001-318 SAME AS 9464R4	07421	R 1	
R7	RES,FXD COMP	RC20GF153J SAME AS 9467R20	44655	R 1	
R8	RES,FXD COMP 100,000 OHMS 1/4 WATT	RC07GF184J	44655	1	0 1
R10,R11	RES,FXD COMP	RC20GF203J SAME AS 9464R8	44655	R 2	
R12	RES,FXD COMP	RC07GF622J SAME AS 94631R30	44655	R 1	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R13	RES,FXD COMP	RC07GF301J SAME AS 9464R11	44655	R 1	
R14	RES,FXD COMP	RC07GF513J SAME AS 9453R5	44655	R 1	
R15	RES,FXD COMP	RC07GF242J SAME AS 9464R13	44655	R 1	
R16	RES,FXD COMP	RC07GF333J SAME AS 9460R23	44655	R 1	
R17-R19	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	R 4	
R20,R21	RES,FXD COMP	RC07GF510J SAME AS 9453R21	44655	R 2	
R22	RES,FXD COMP	RC07GF511J SAME AS 94631R28	44655	REF	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
94527	SWITCH ASSEMBLY	9452700	07421	R 1	
C1	CAP.FXD PAPER 0.033MFD 10% 100 VDCW	323-001-019 WE1-333E	07421 99515	4	0 1
C2	CAP.FXD PAPER	323-001-013 SAME AS 9453C3	07421	R 4	
C3	CAP.FXD MICA 3,300 MMF 5% B VV- T	DM20-332J	84171	2	0 1
C4	CAP.FXD MICA 1,100 MMF 5% B VV- T	DM20-112J	84171	2	0 1
C5	CAP.FXD MICA	321-001-046 SAME AS 9465C8	07421	R 2	
C6	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	R 4	
C7	CAP.FXD MICA 3300 MMF 5% 500 VDCW	321-003-018 DM20-332J	07421 84171	2	0 1
C8	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C9	CAP.FXD PAPER	323-001-019 SAME AS 94527C1	07421	REF	
C10	CAP.FXD PAPER	323-001-013 SAME AS 9453C3	07421	REF	
C11	CAP.FXD MICA	321-003-014 SAME AS 9453C6	07421	R 2	
C12	CAP.FXD MICA 620 MMF 5% 300 VDCW	321-001-048 DM15-621J	07421 84171	2	0 1
C13	CAP.FXD PAPER	323-001-019 SAME AS 94527C1	07421	REF	
C14	CAP.FXD PAPER	323-001-013 SAME AS 9453C3	07421	REF	
C15	CAP.FXD MICA	DM20-332J SAME AS 94527C3	84171	REF	
C16	CAP.FXD MICA	DM20-112J SAME AS 94527C4	84171	REF	
C17	CAP.FXD MICA	321-001-046 SAME AS 9465C8	07421	REF	
C18	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
C19	CAP.FXD MICA	321-003-018 SAME AS 94527C7	07421	REF	
C20	CAP.FXD PAPER	323-001-025 SAME AS 9453C4	07421	REF	
C21	CAP.FXD PAPER	323-001-019 SAME AS 94527C1	07421	REF	
C22	CAP.FXD PAPER	323-001-013 SAME AS 9453C3	07421	REF	
C23	CAP.FXD MICA	321-003-014 SAME AS 9453C6	07421	REF	
C24	CAP.FXD MICA	321-001-048 SAME AS 94527C12	07421	REF	
FL1,FL2	FILTER,LOW PASS	16200055	07421	2	0 1
S1,S2	SWITCH,DEMOD	9451500	07421	2	0 1

Chapter 7

MAINTENANCE DIAGRAMS

This chapter contains maintenance diagrams for Tracking Filter Models PL300 - PL307. Figure 7-1 is a chassis layout diagram showing the location of all plug-in modules and circuit cards. Figure 7-2 is a power distribution diagram. Figures 7-3 through 7-23 are schematic diagrams of all plug-in modules and circuit cards. The tracking filter loop control relay logic is illustrated in figure 7-24, and a combination schematic and block diagram of the overall filter assembly is presented in figure 7-25.

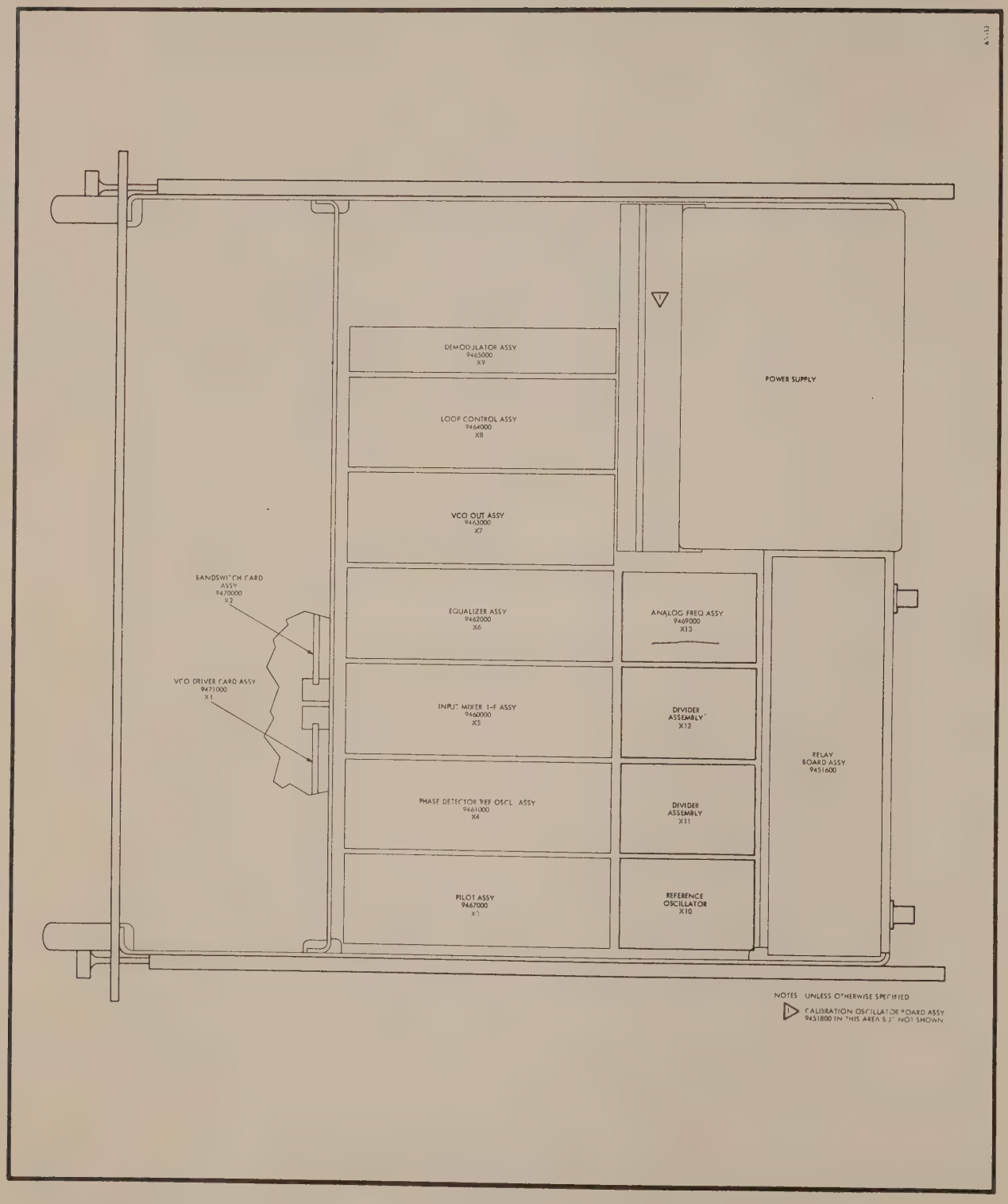


Figure 7-1. Phase Lock Tracking Filter Model PL307, Chassis Layout Diagram

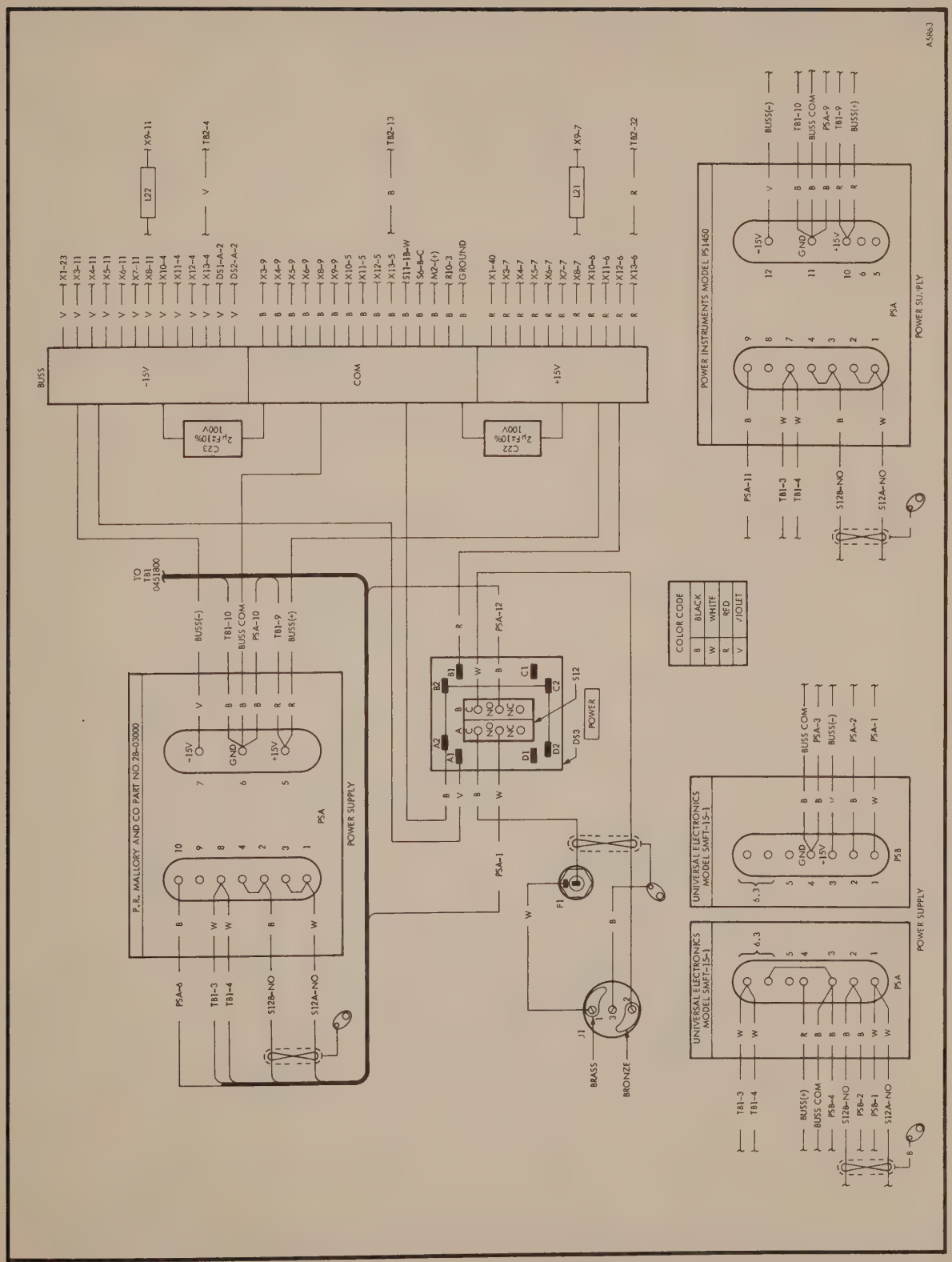


Figure 7-2. Phase Lock Tracking Filter Models PL 300 - PL 307, Power Distribution Diagram

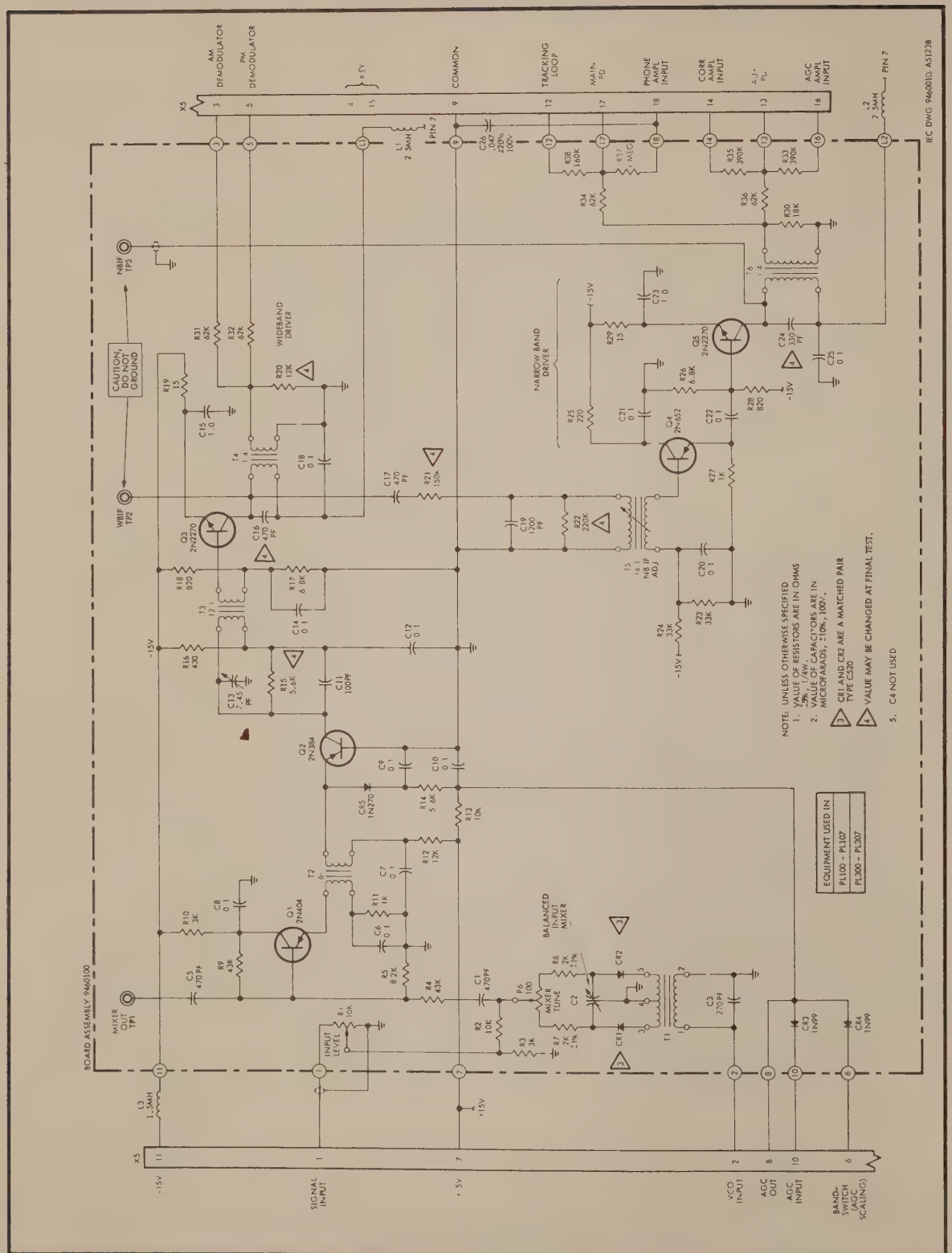


Figure 7-3. Input Mixer/I-F Amplifier Assembly 9460000, Schematic Diagram

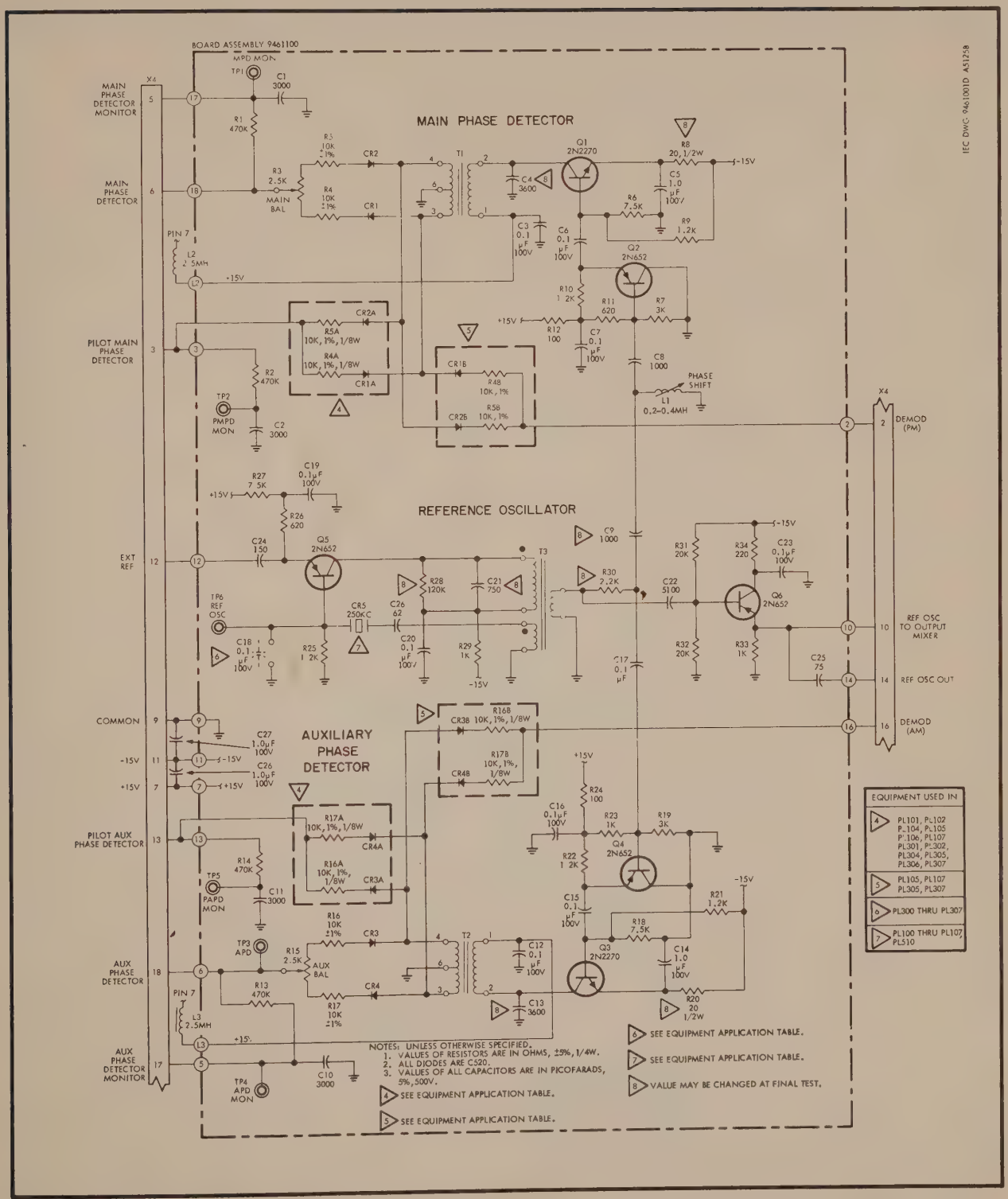


Figure 7-4. Phase Detector/Reference Oscillator Assembly 9461000, Schematic Diagram

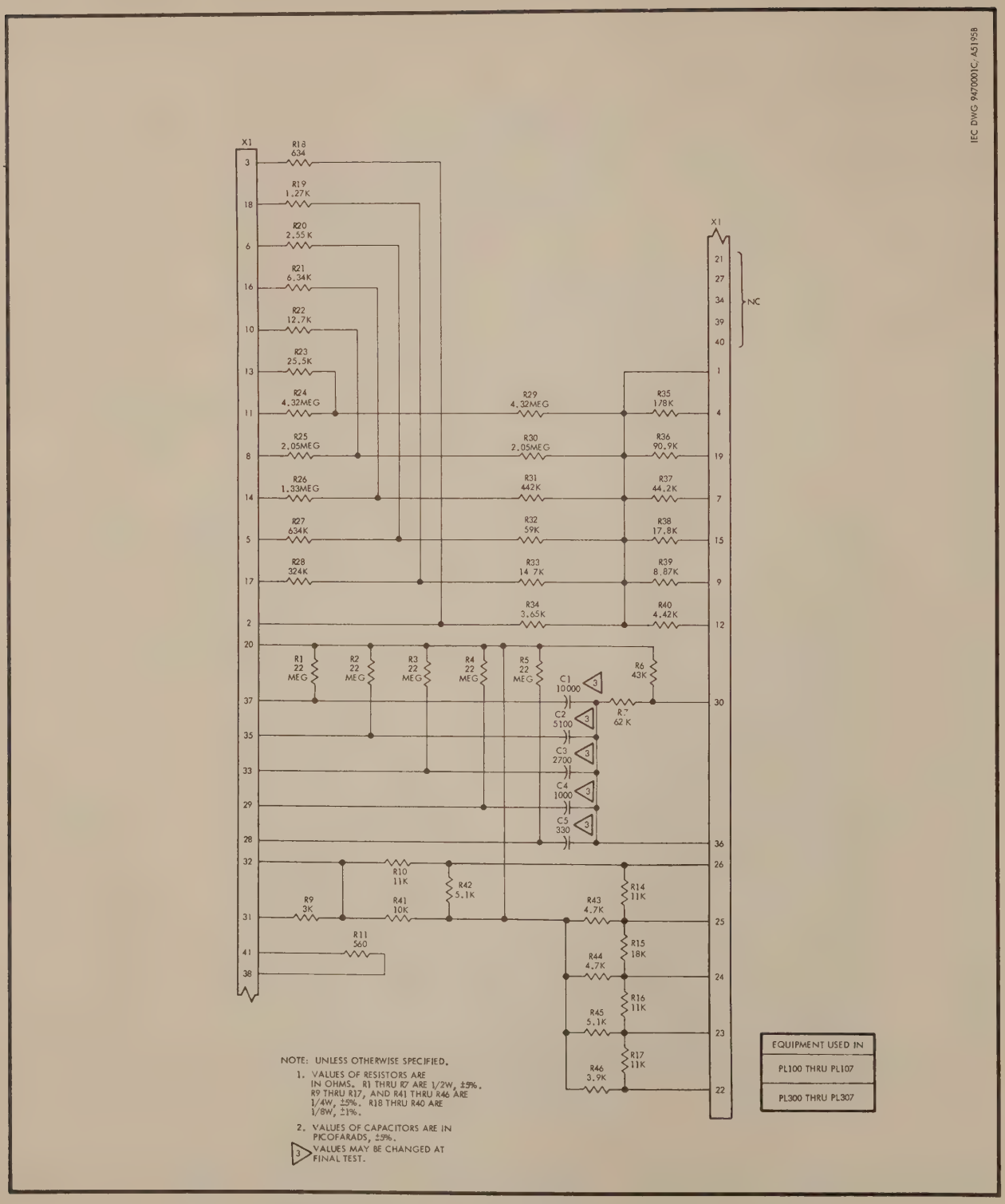


Figure 7-5. Bandswitch Assembly 9470000, Schematic Diagram

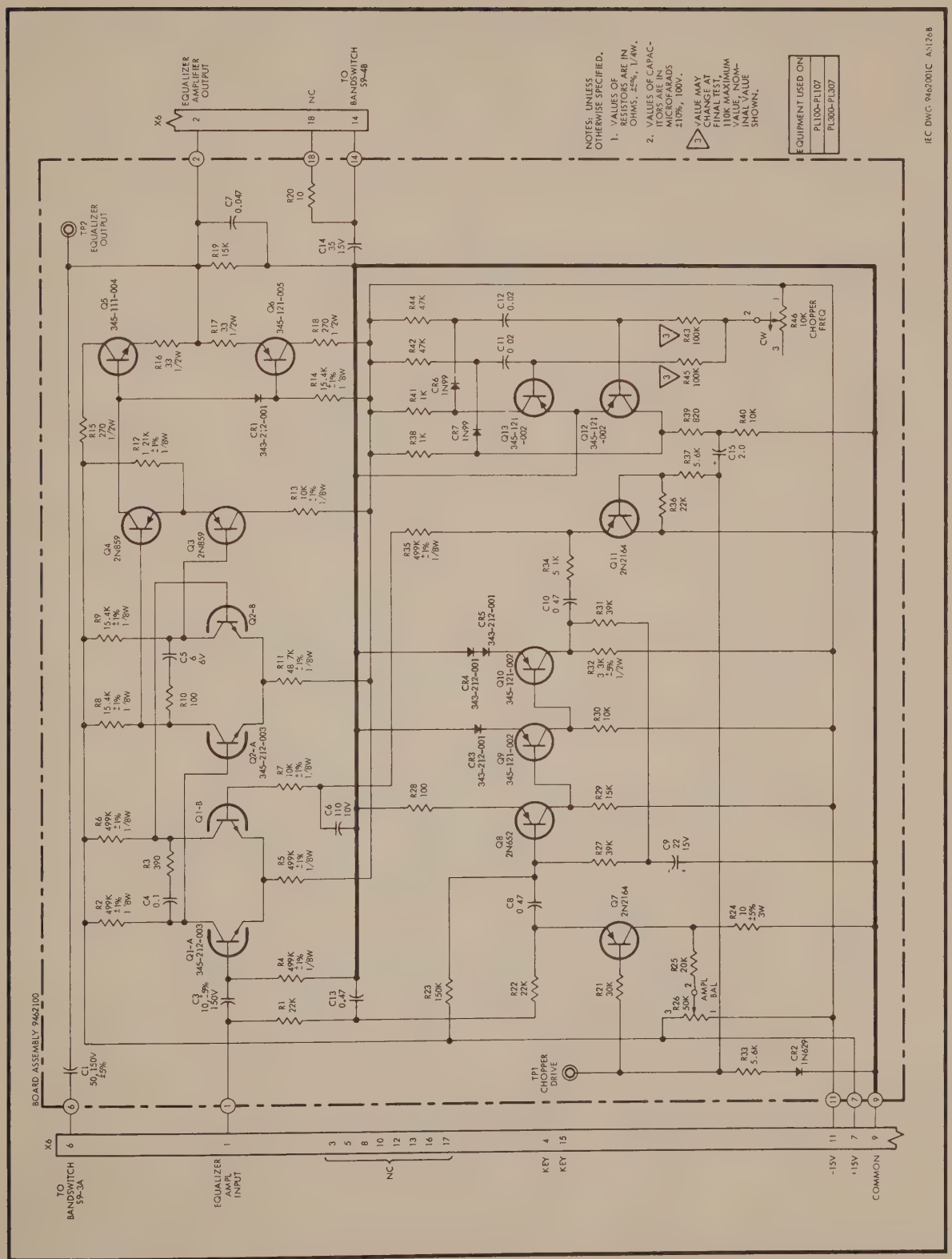


Figure 7-6. Equalizer Amplifier Assembly 9462000, Schematic Diagram

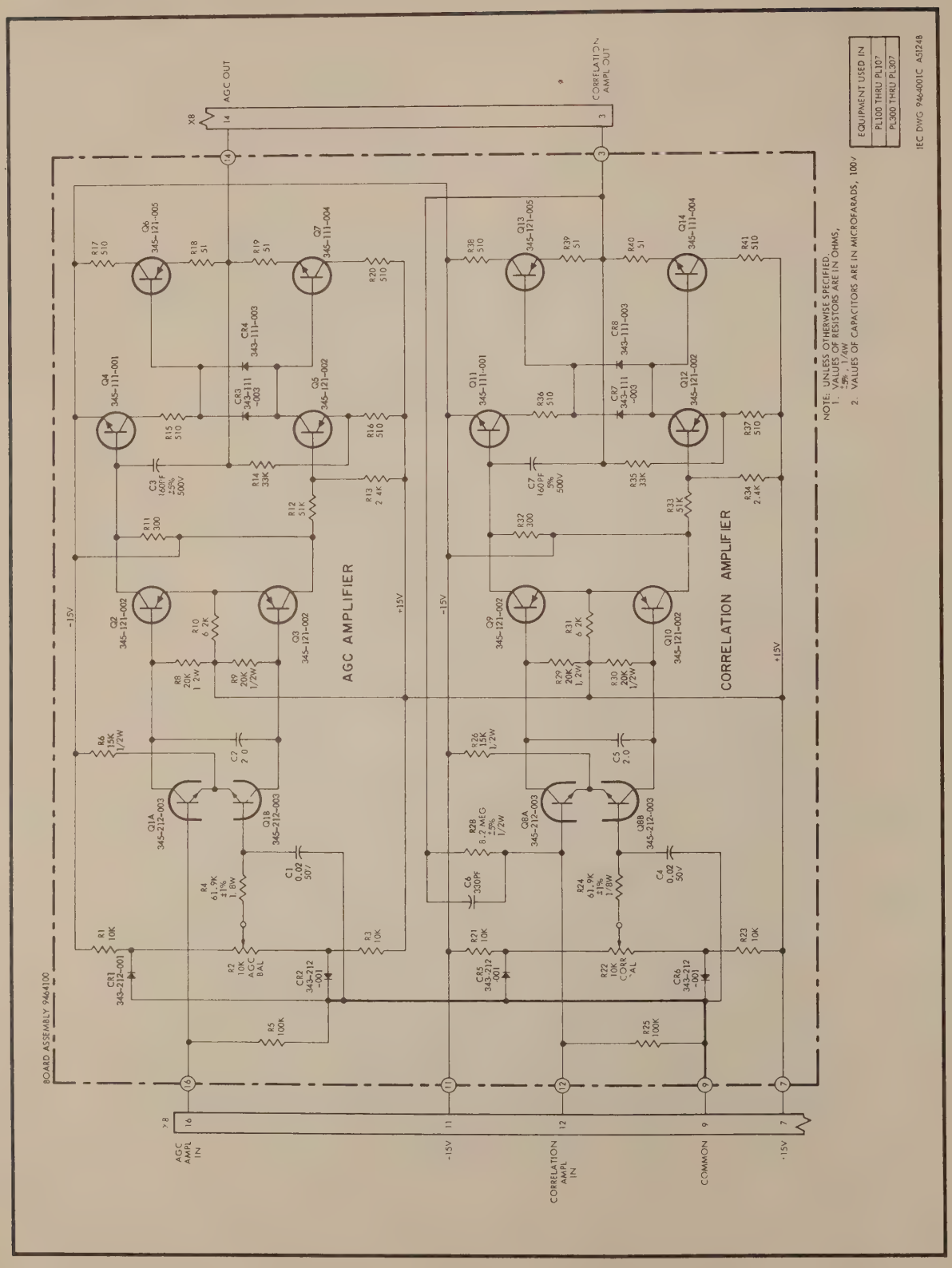


Figure 7-7. Loop Control Assembly 9464000, Schematic Diagram (Sheet 1 of 2)

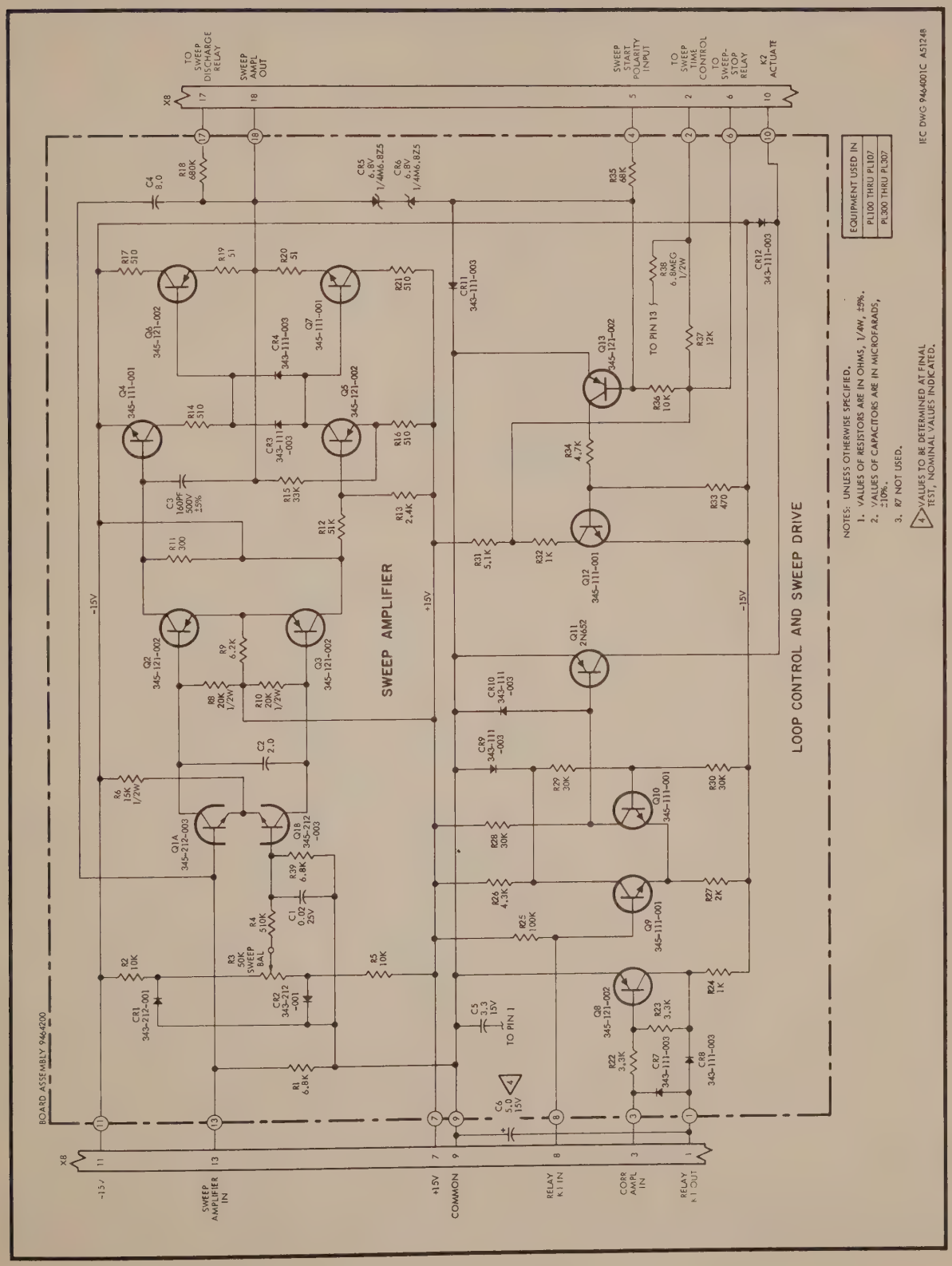


Figure 7-7. Loop Control Assembly 9464000, Schematic Diagram (Sheet 2 of 2)

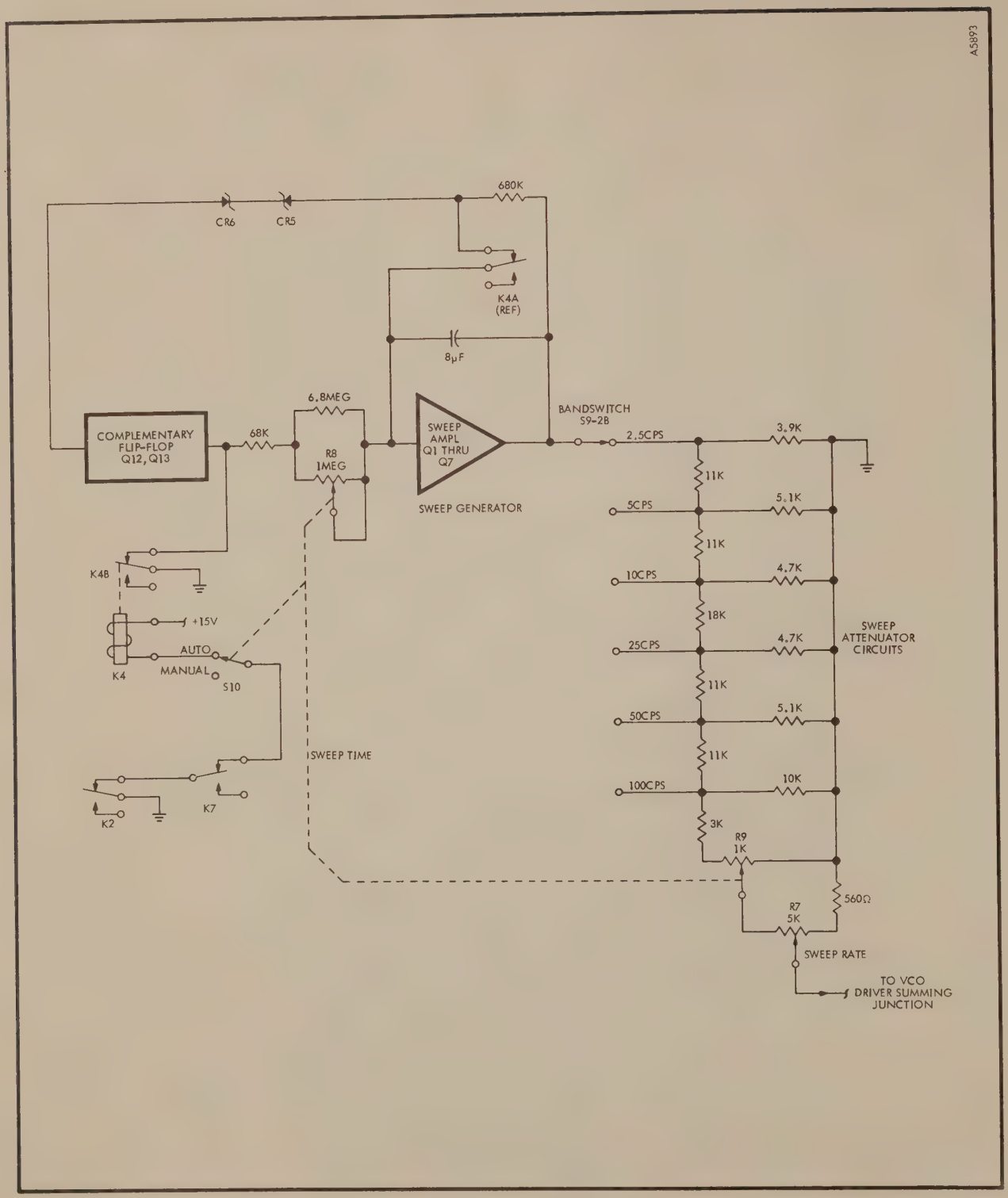


Figure 7-8. Sweep Control, Simplified Schematic Diagram

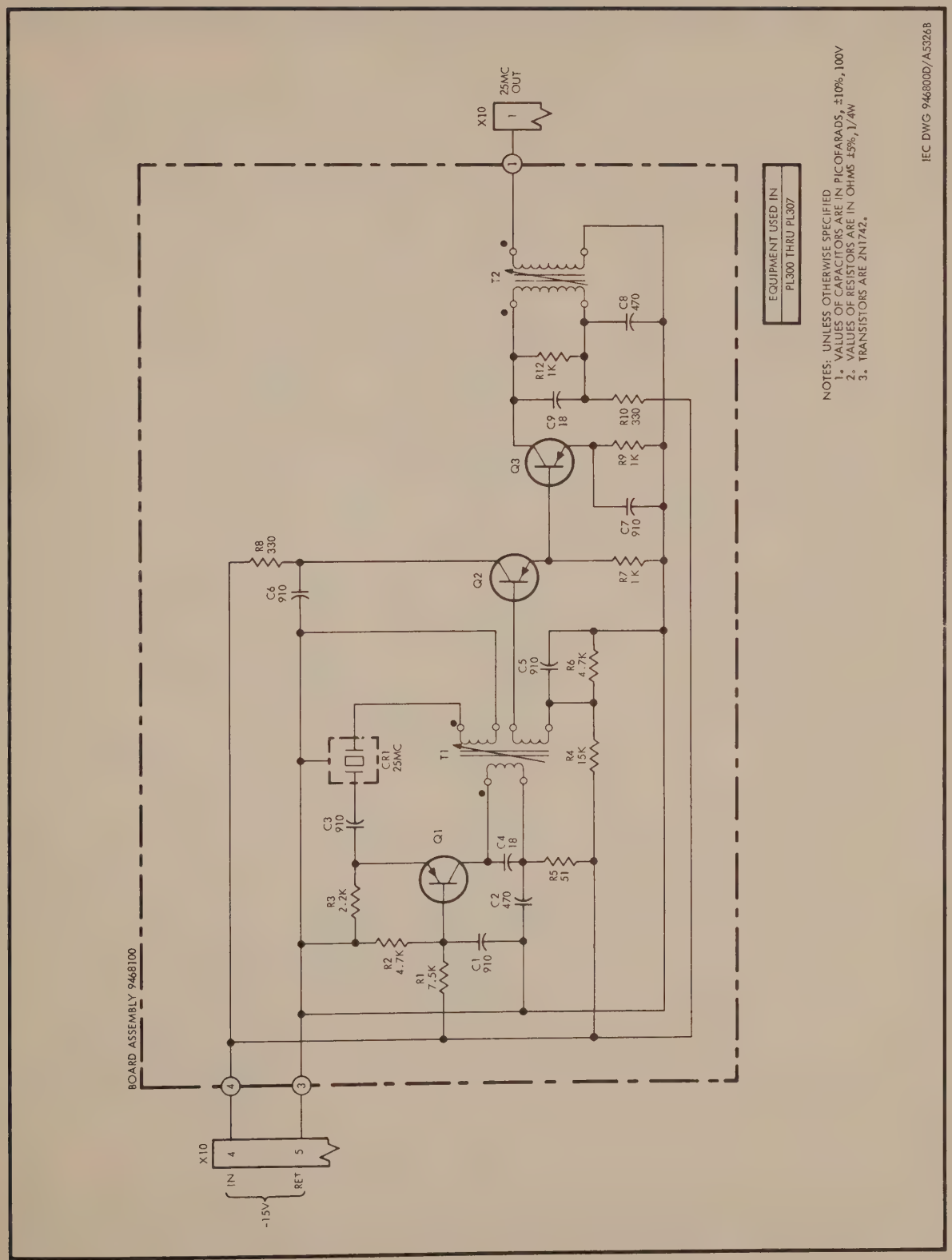


Figure 7-9. Reference Oscillator Assembly 9468000, Schematic Diagram

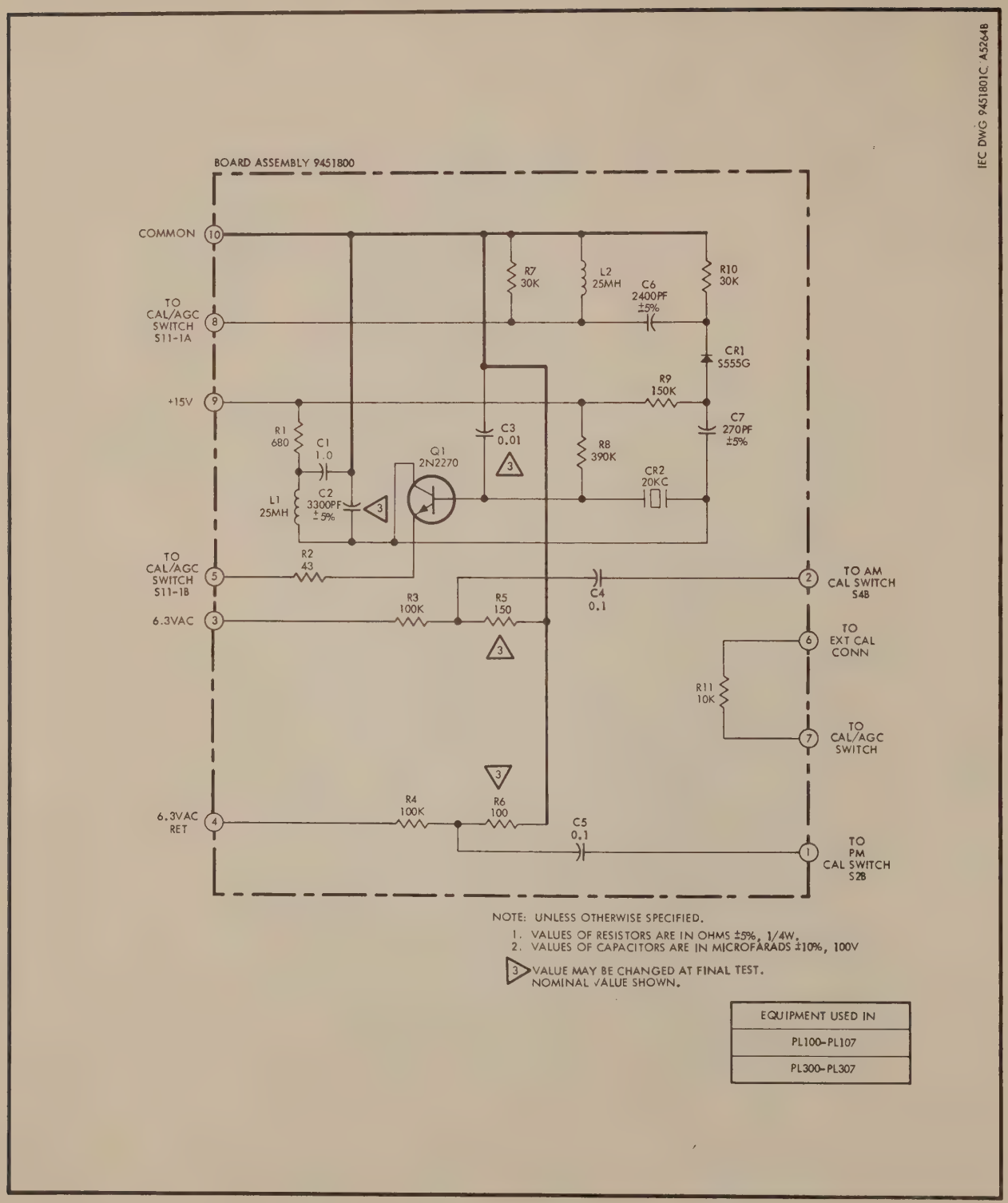


Figure 7-10. Calibration Oscillator 9451800, Schematic Diagram

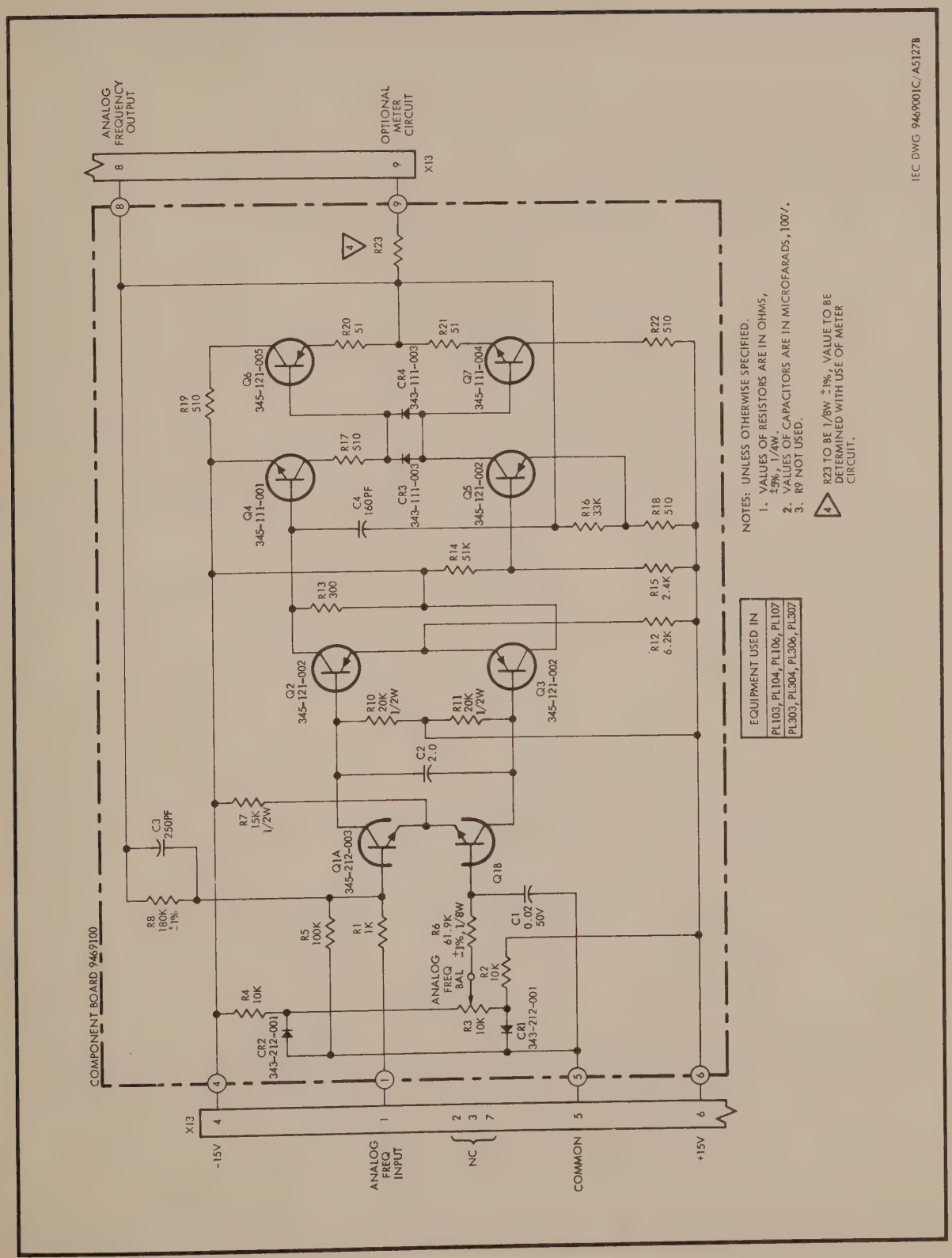


Figure 7-11. Analog Frequency Amplifier Assembly 9469000, Schematic Diagram

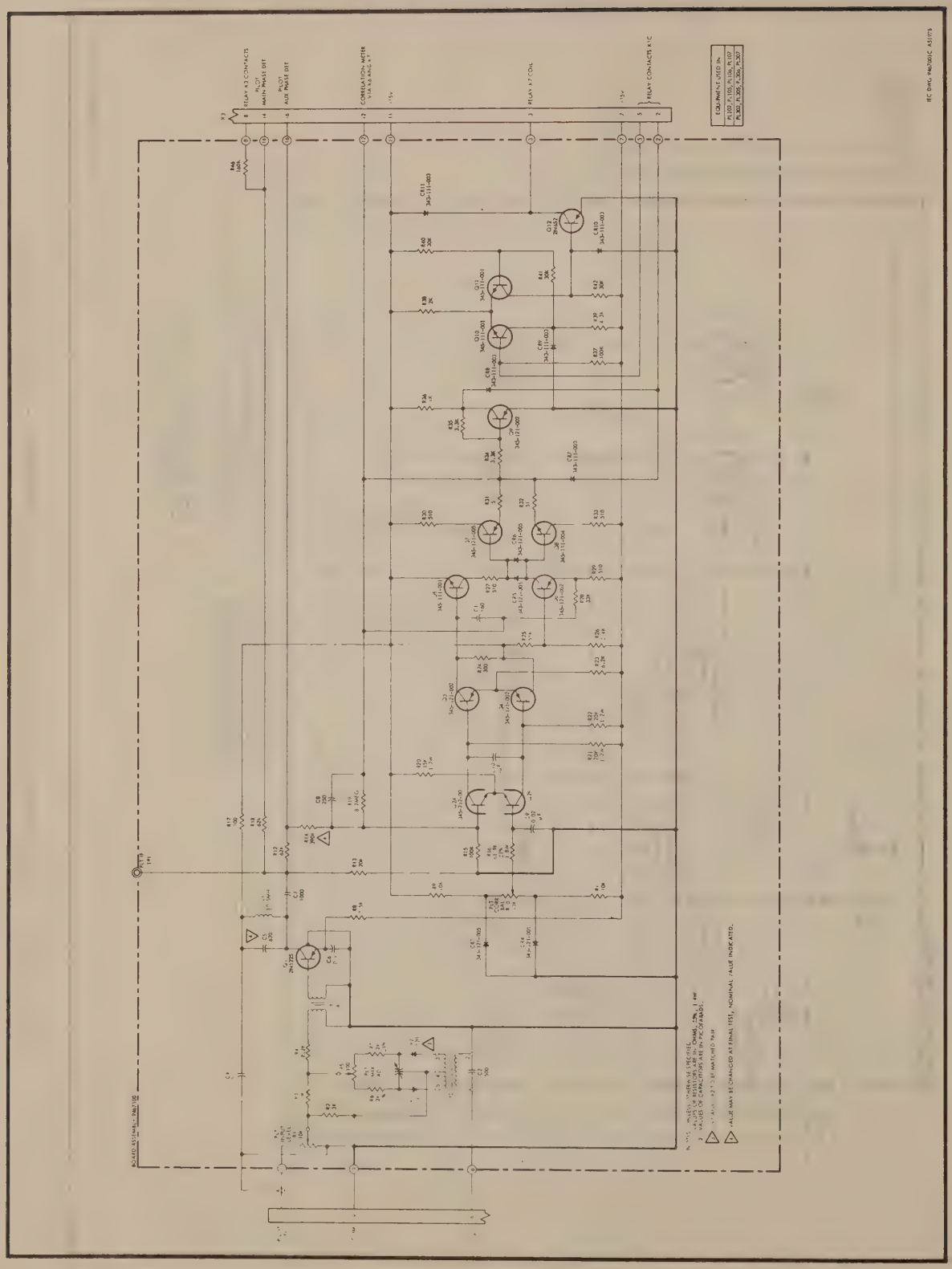


Figure 7-12. Pilot Assembly 9467000, Schematic Diagram

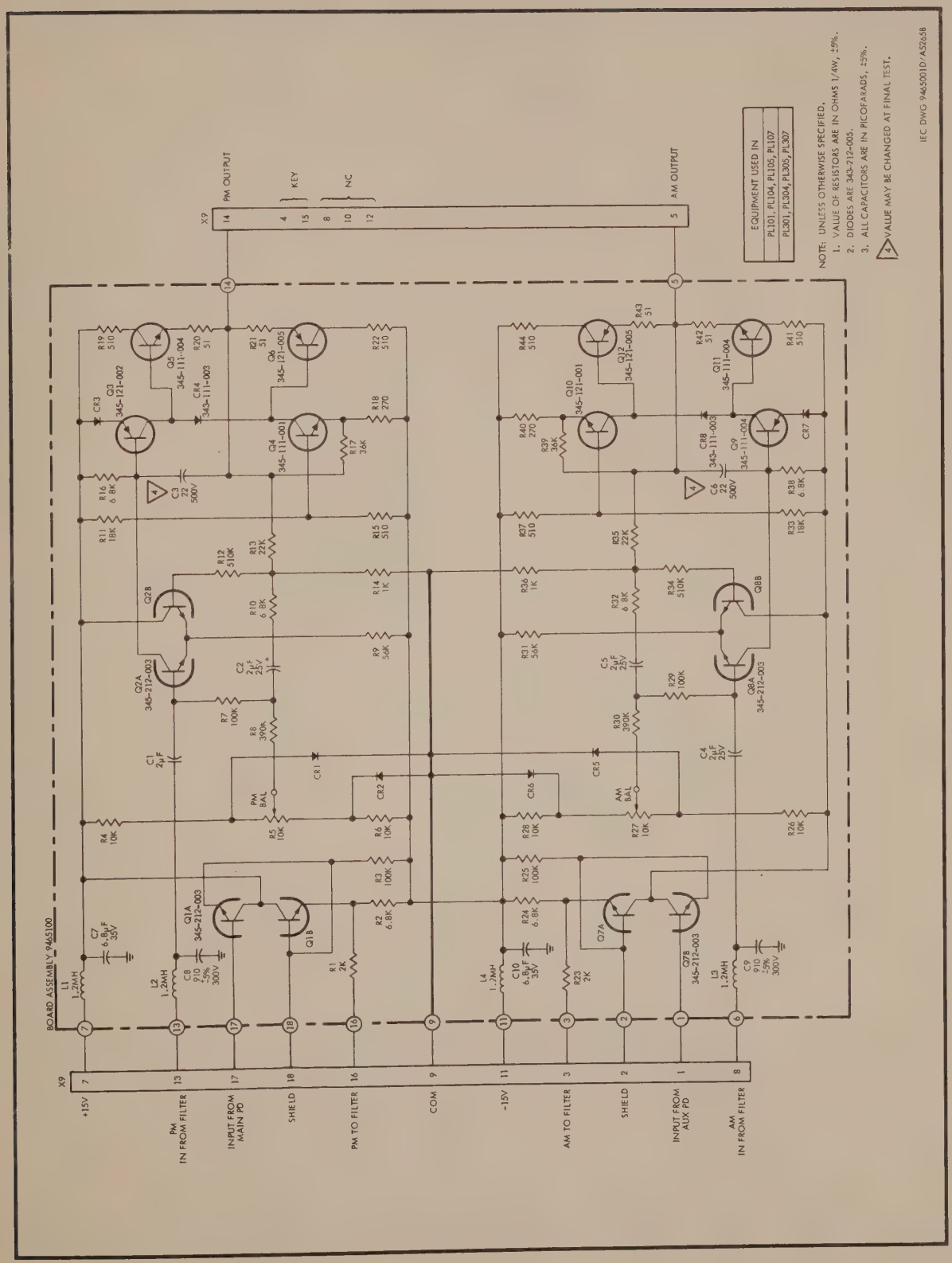


Figure 7-13. Demodulator Amplifier Assembly 9465000, Schematic Diagram

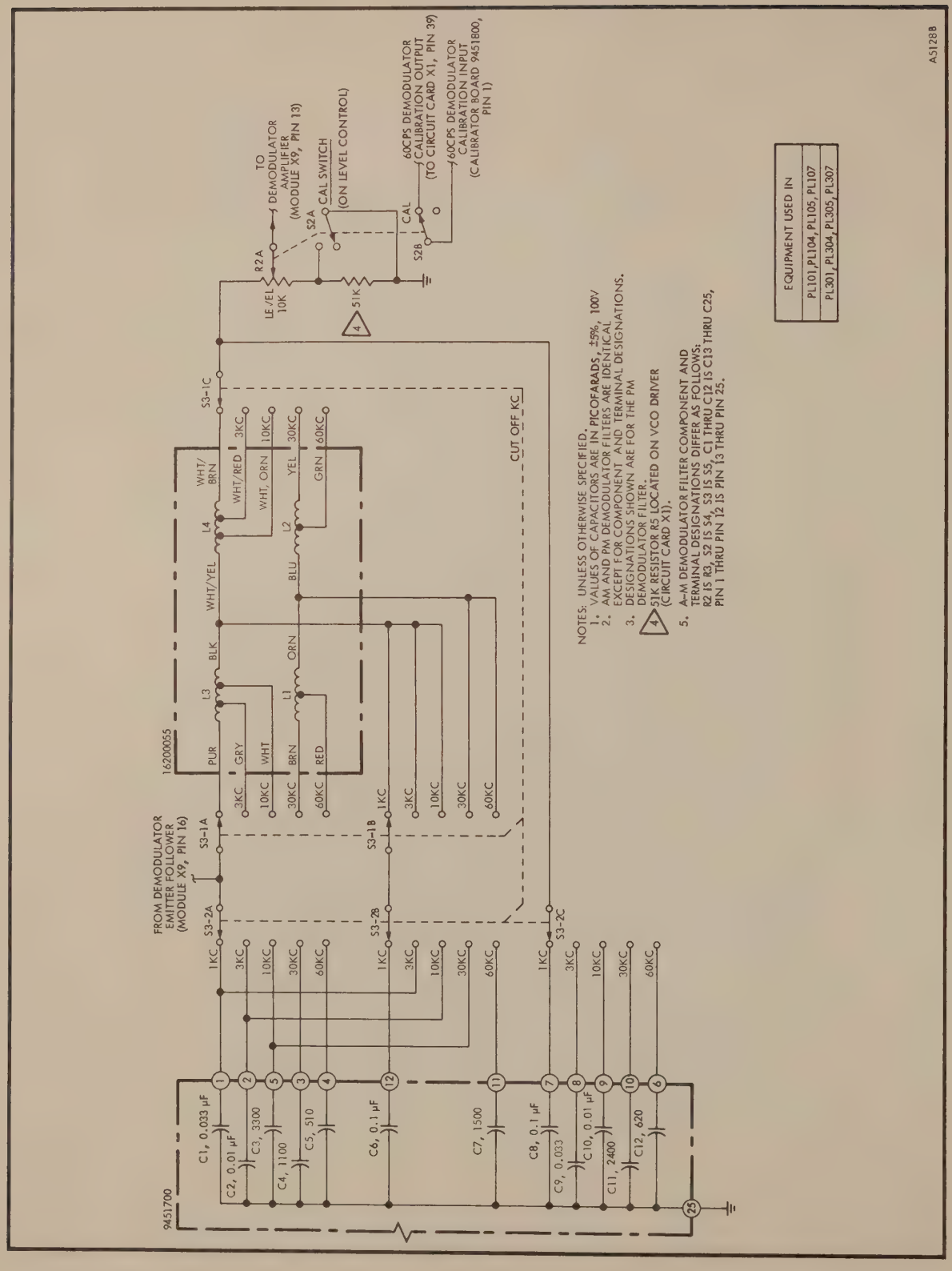


Figure 7-14. Demodulator Low-Pass Filter, Simplified Schematic Diagram

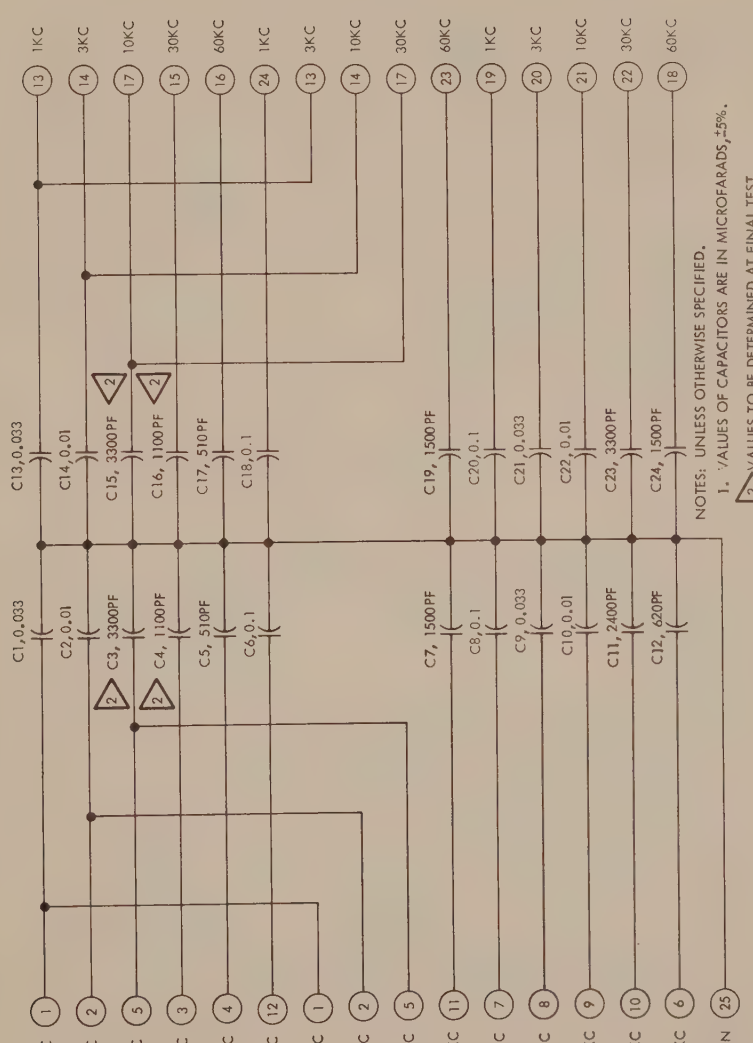


Figure 7-15. Demodulator Capacitor Board Assembly 9451700, Schematic Diagram

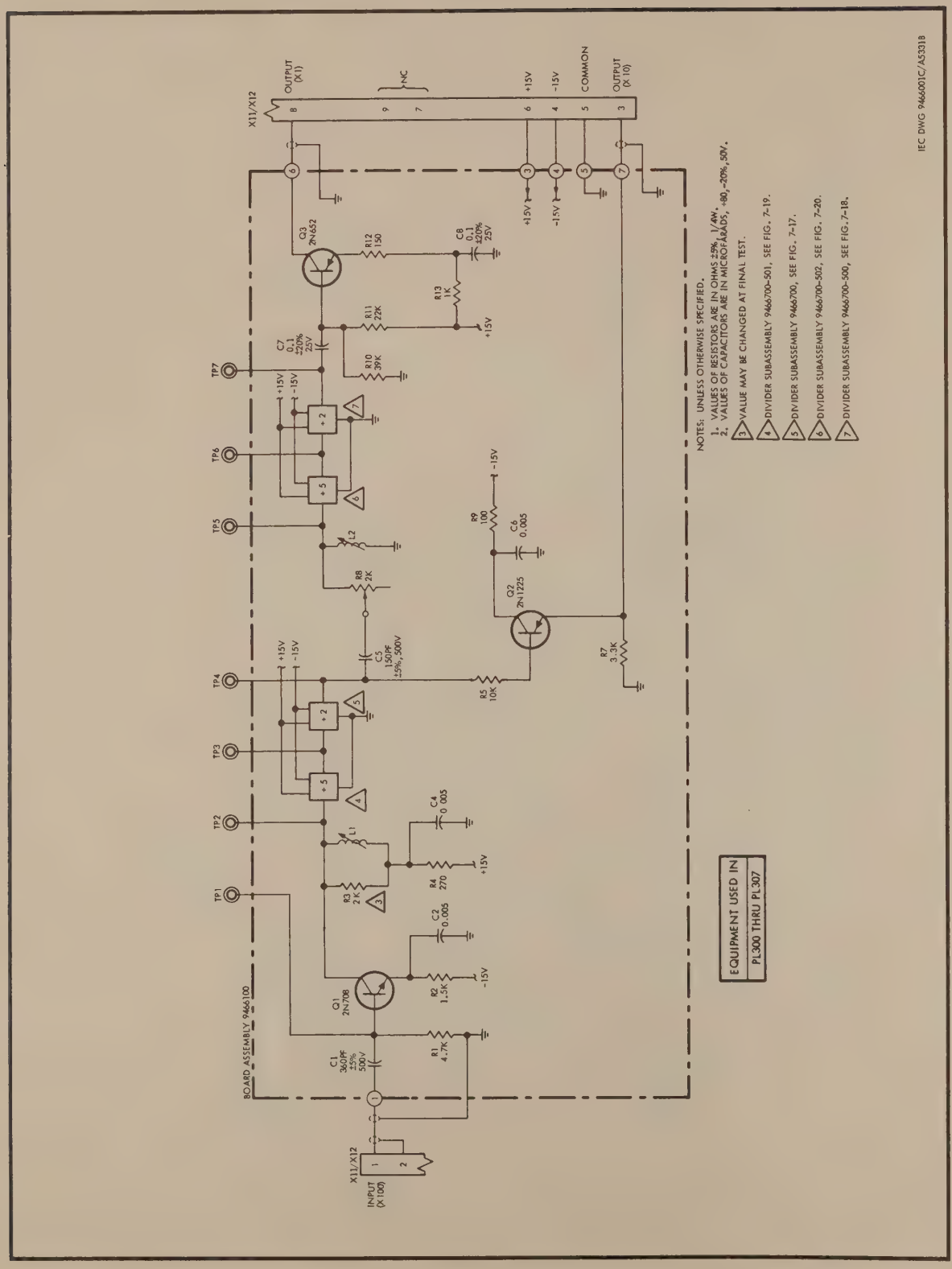


Figure 7-16. Divider Assembly 9466000, Schematic Diagram

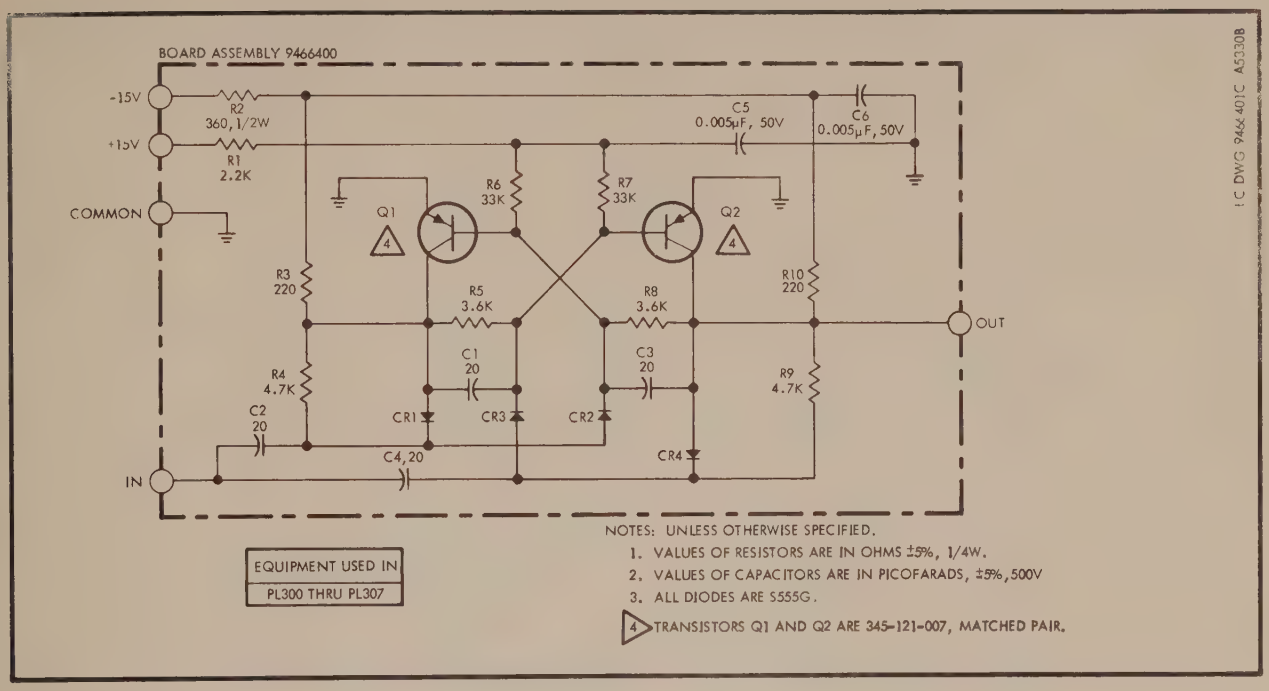


Figure 7-17. Divider Subassembly 9466700 (High Frequency, N/2), Schematic Diagram

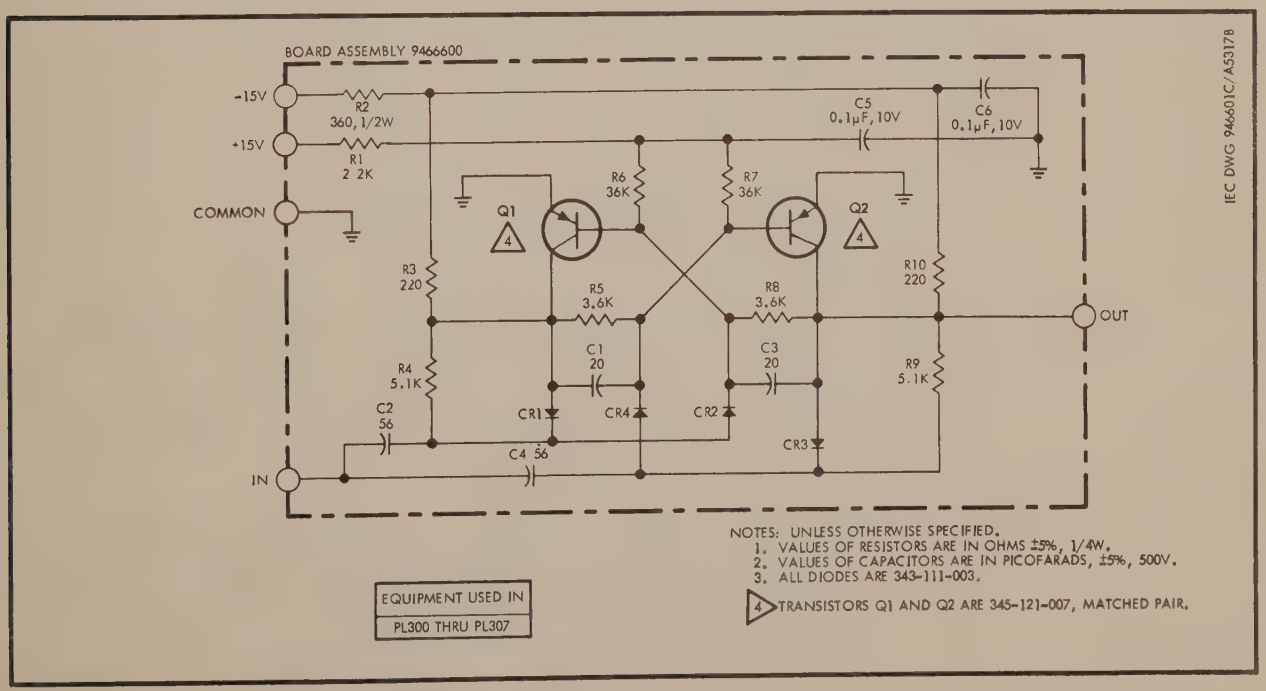


Figure 7-18. Divider Subassembly 9466700-500 (Low Frequency, N/2), Schematic Diagram

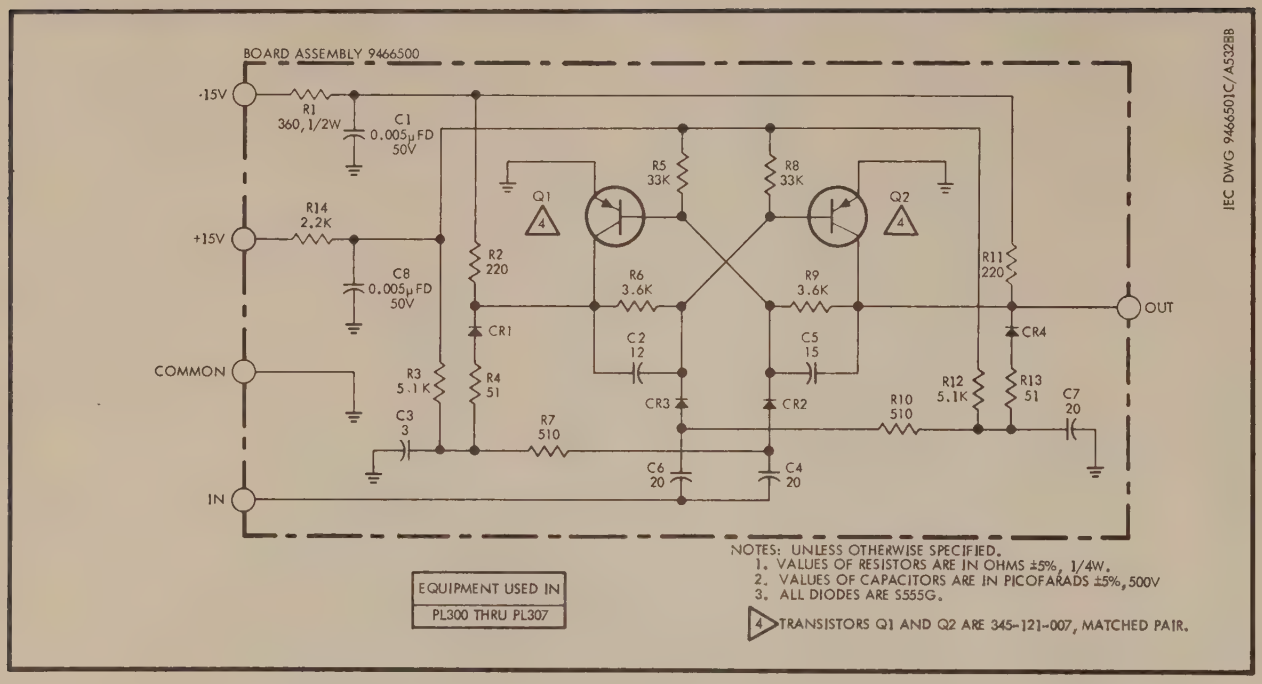


Figure 7-19. Divider Subassembly 9466700-501 (High Frequency, N/5), Schematic Diagram

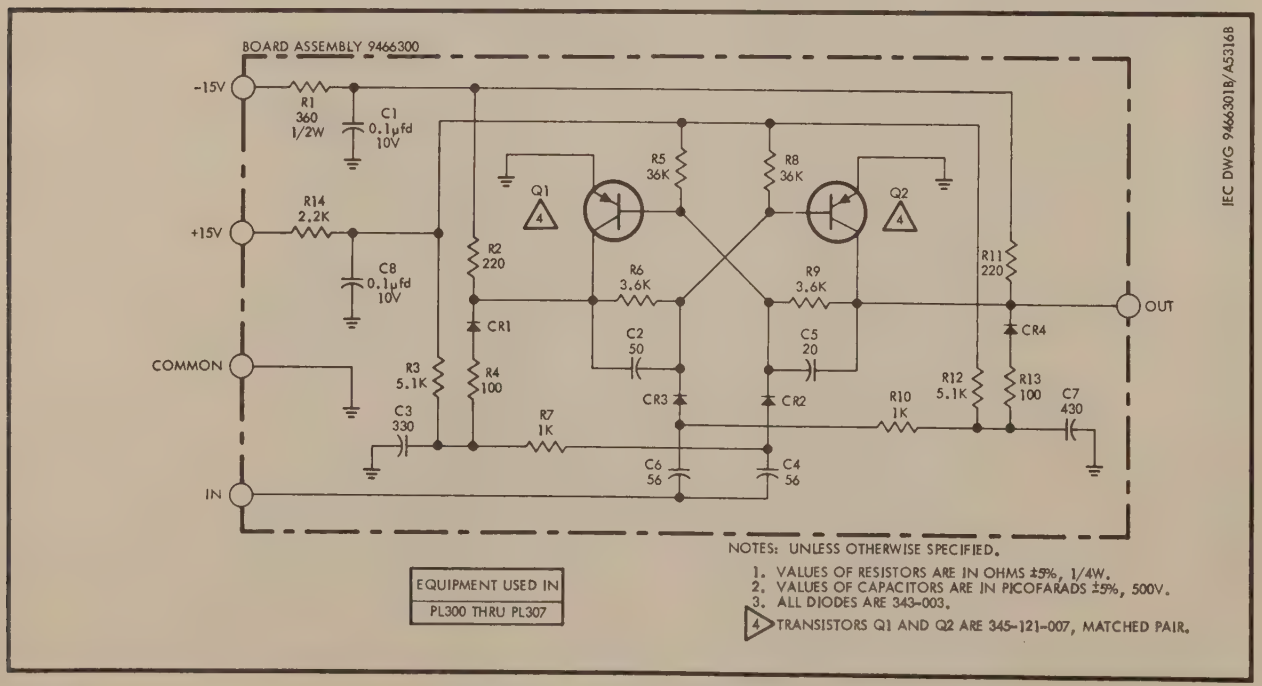


Figure 7-20. Divider Subassembly 9466700-502 (Low Frequency, N/5), Schematic Diagram

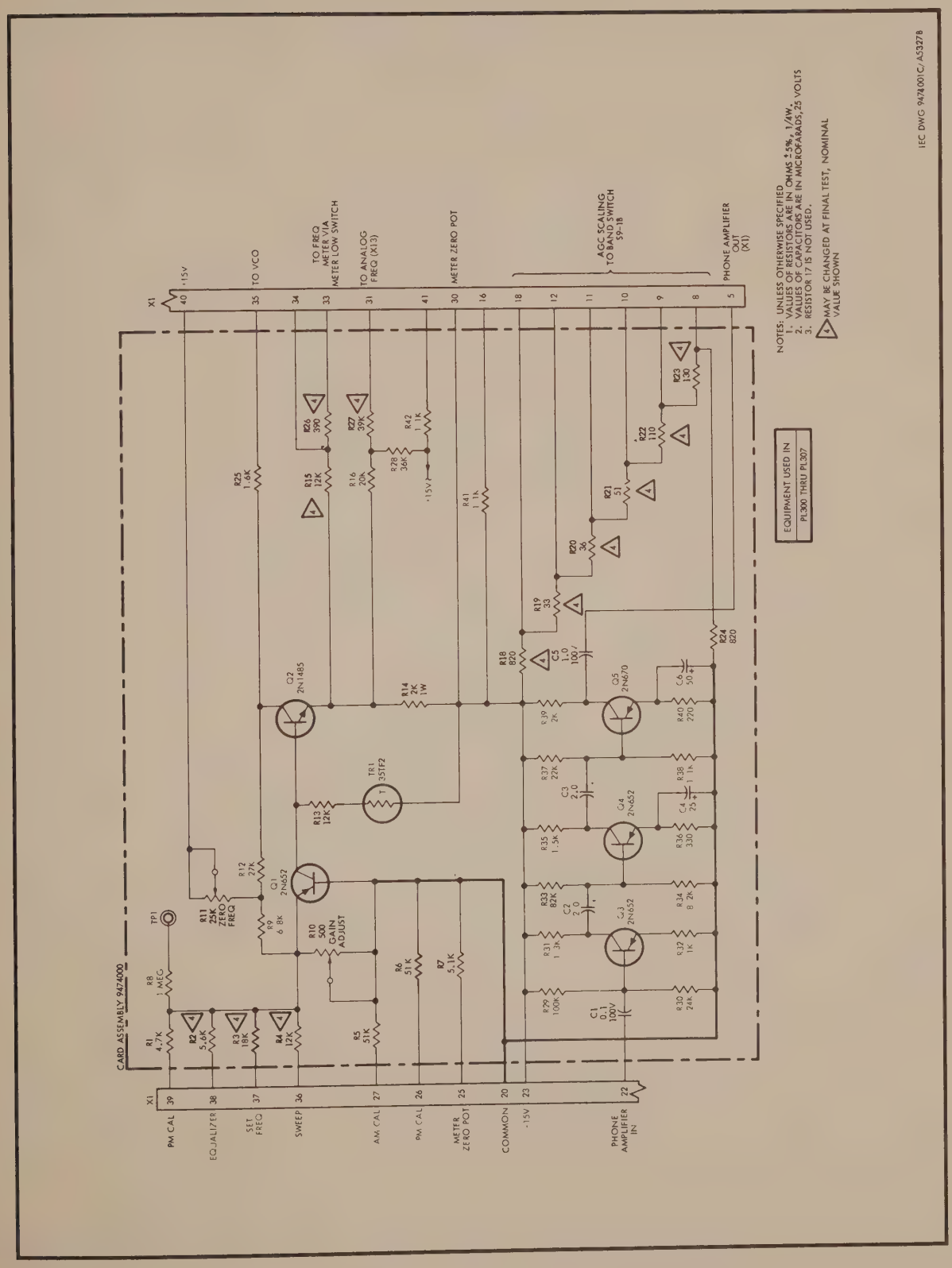


Figure 7-21. VCO Driver Assembly 9474000, Schematic Diagram

NOTES

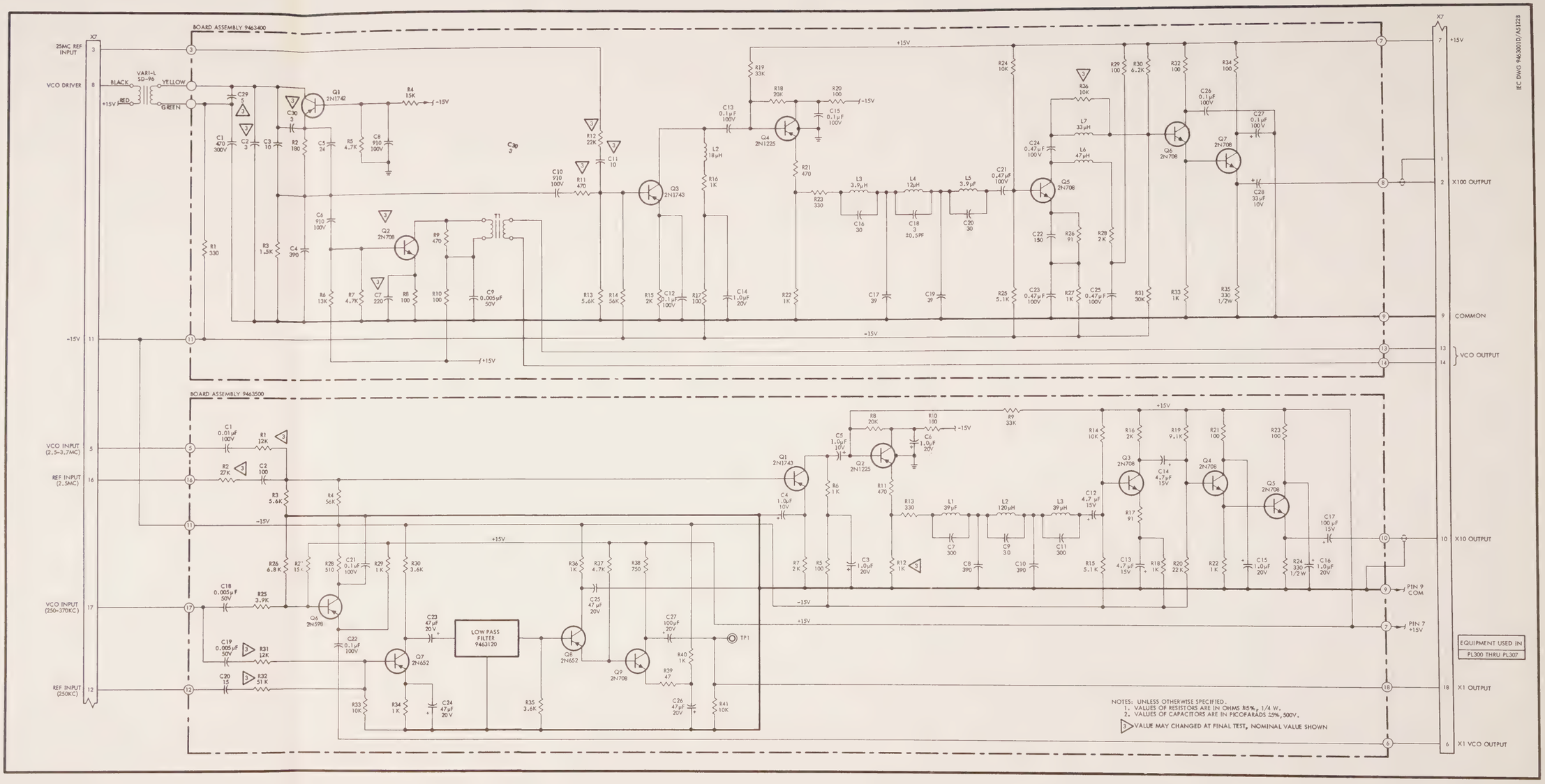


Figure 7-22. Voltage Controlled Oscillator Assembly 9463000-501, Schematic Diagram

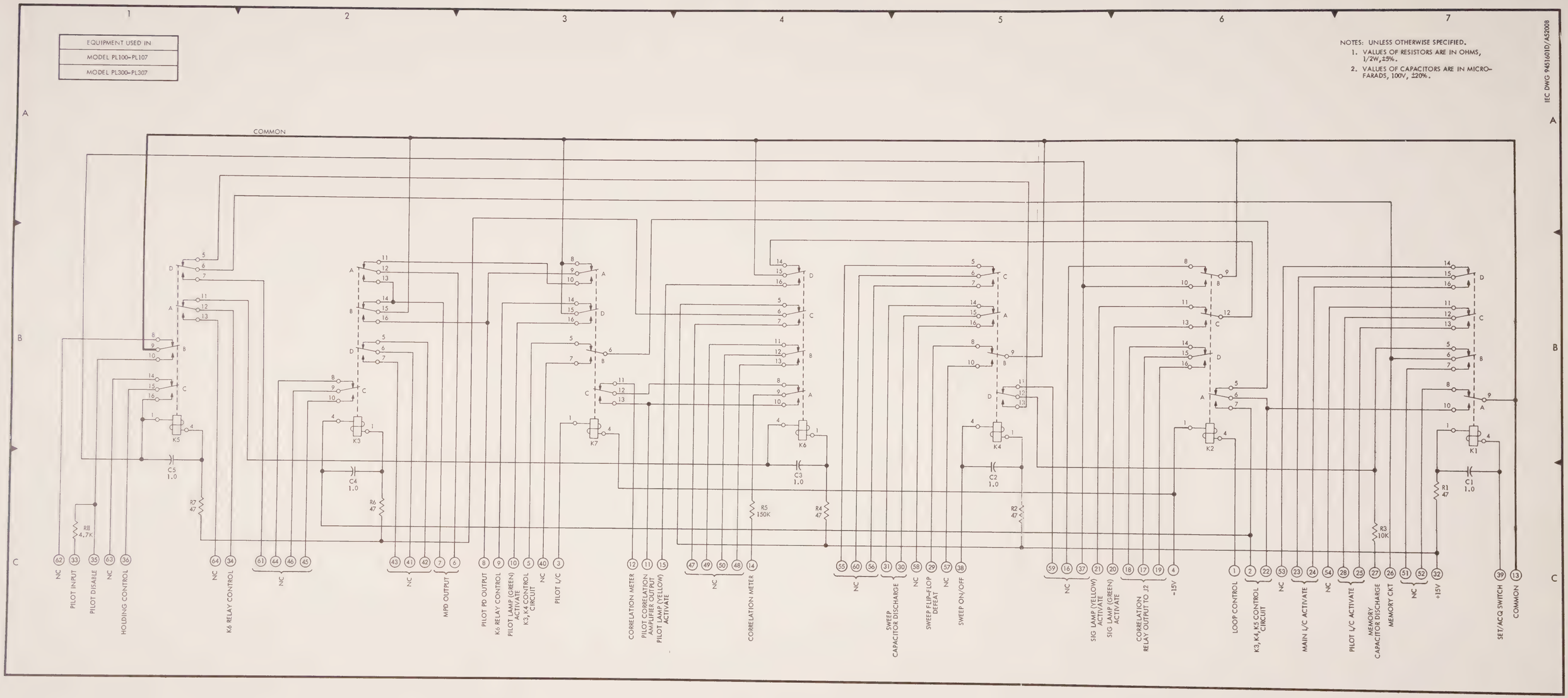


Figure 7-23. Relay Board Assembly 9451600, Schematic Diagram

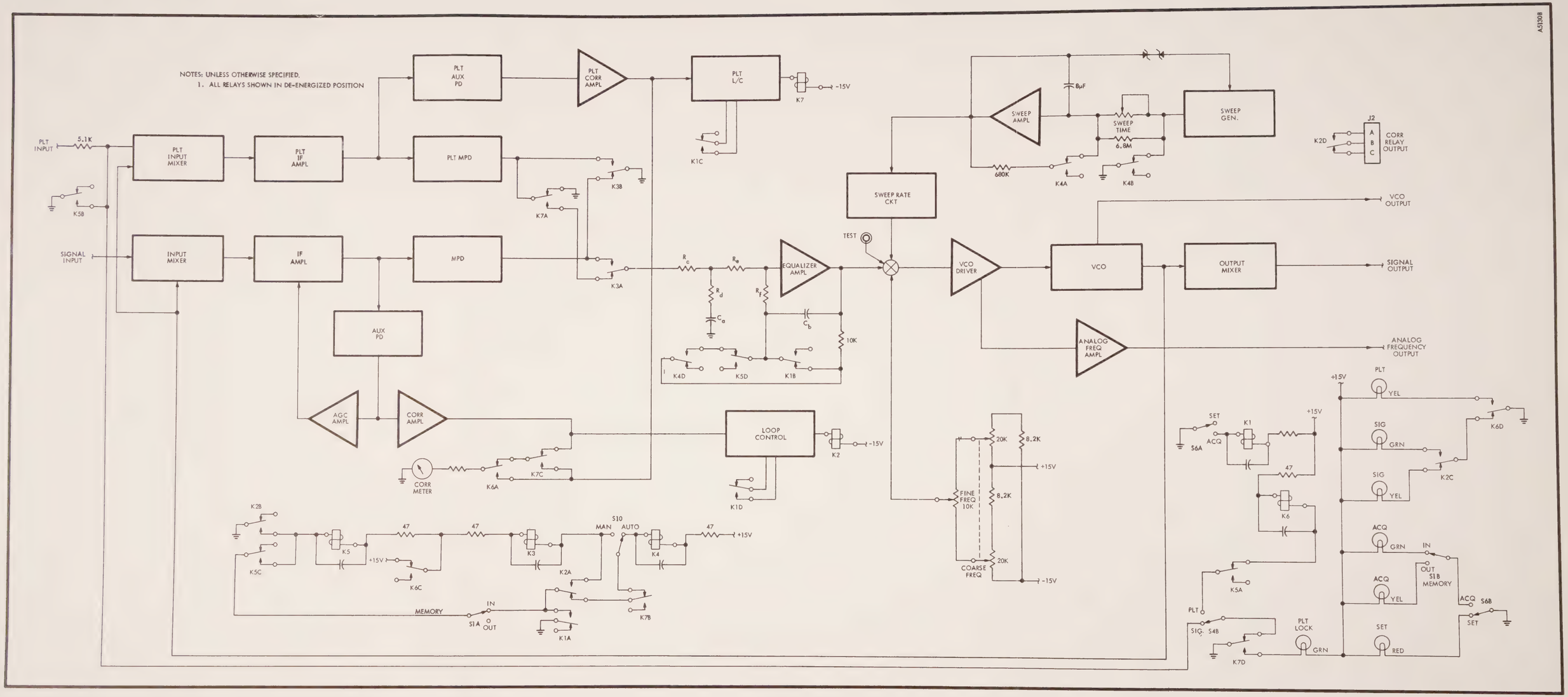
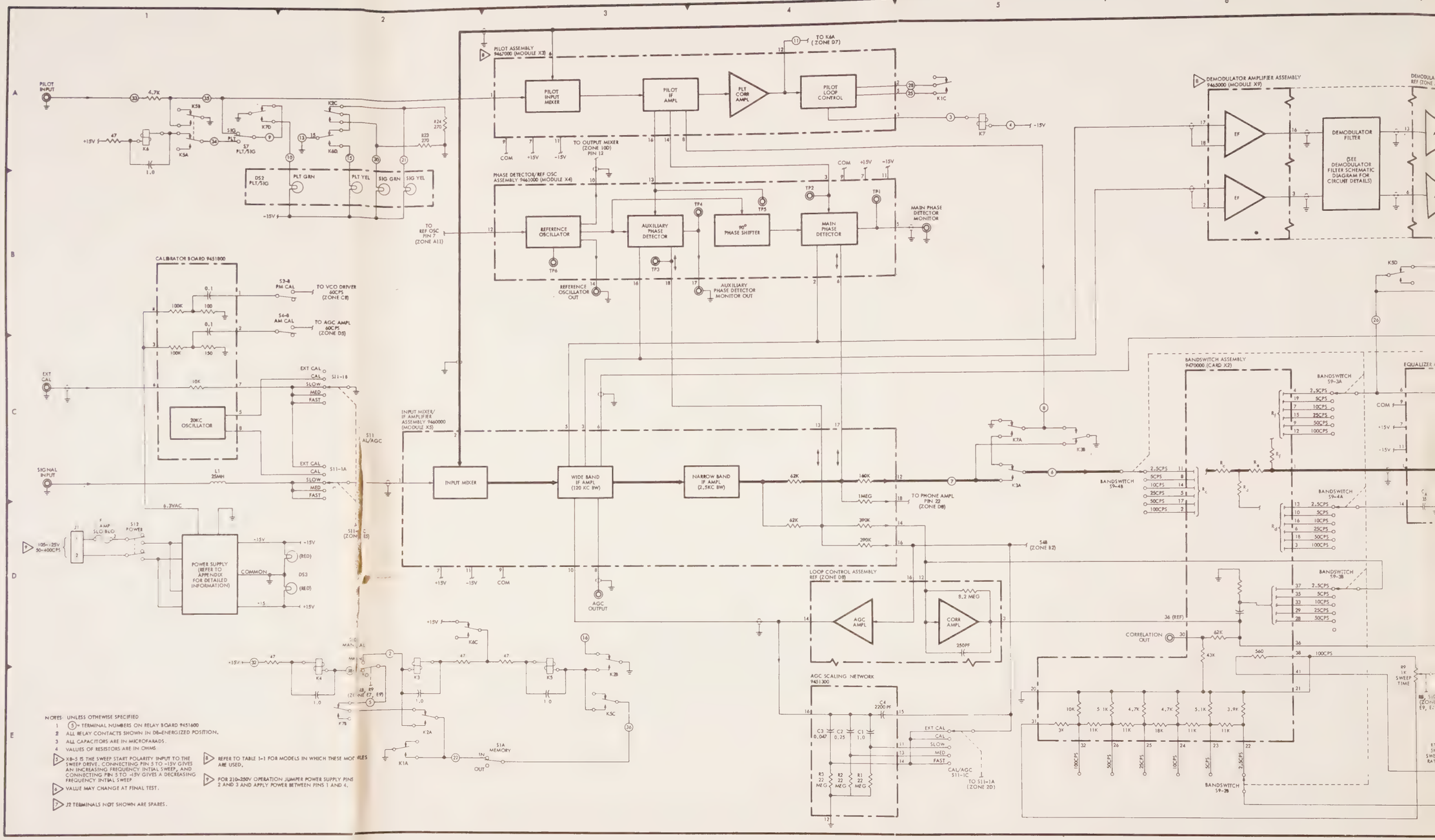


Figure 7-24. Loop Control Relay Logic Diagram



NOTES: UNLESS OTHERWISE SPECIFIED:

1. (5)= TERMINAL NUMBERS ON RELAY BOARD 9451600
2. ALL RELAY CONTACTS SHOWN IN DE-ENERGIZED POSITION.
3. ALL CAPACITORS ARE IN MICROFARADS.
4. VALUES OF RESISTORS ARE IN OHMS

▷ X8-5 IS THE SWEEP START POLARITY INPUT TO THE SWEEP DRIVE. CONNECTING PIN 5 TO -15V GIVES AN INCREASING FREQUENCY INTIAL SWEEP, AND CONNECTING PIN 5 TO +15V GIVES A DECREASING FREQUENCY INTIAL SWEEP

▷ VALUE MAY CHANGE AT FINAL TEST.

▷ J2 TERMINALS NOT SHOWN ARE SPARES.

▷ REFER TO TABLE 1-1 FOR MODELS IN WHICH THESE MOD RLES ARE USED.

▷ FOR 210-250V OPERATION JUMPER POWER SUPPLY PINS 2 AND 3 AND APPLY POWER BETWEEN PINS 1 AND 4.

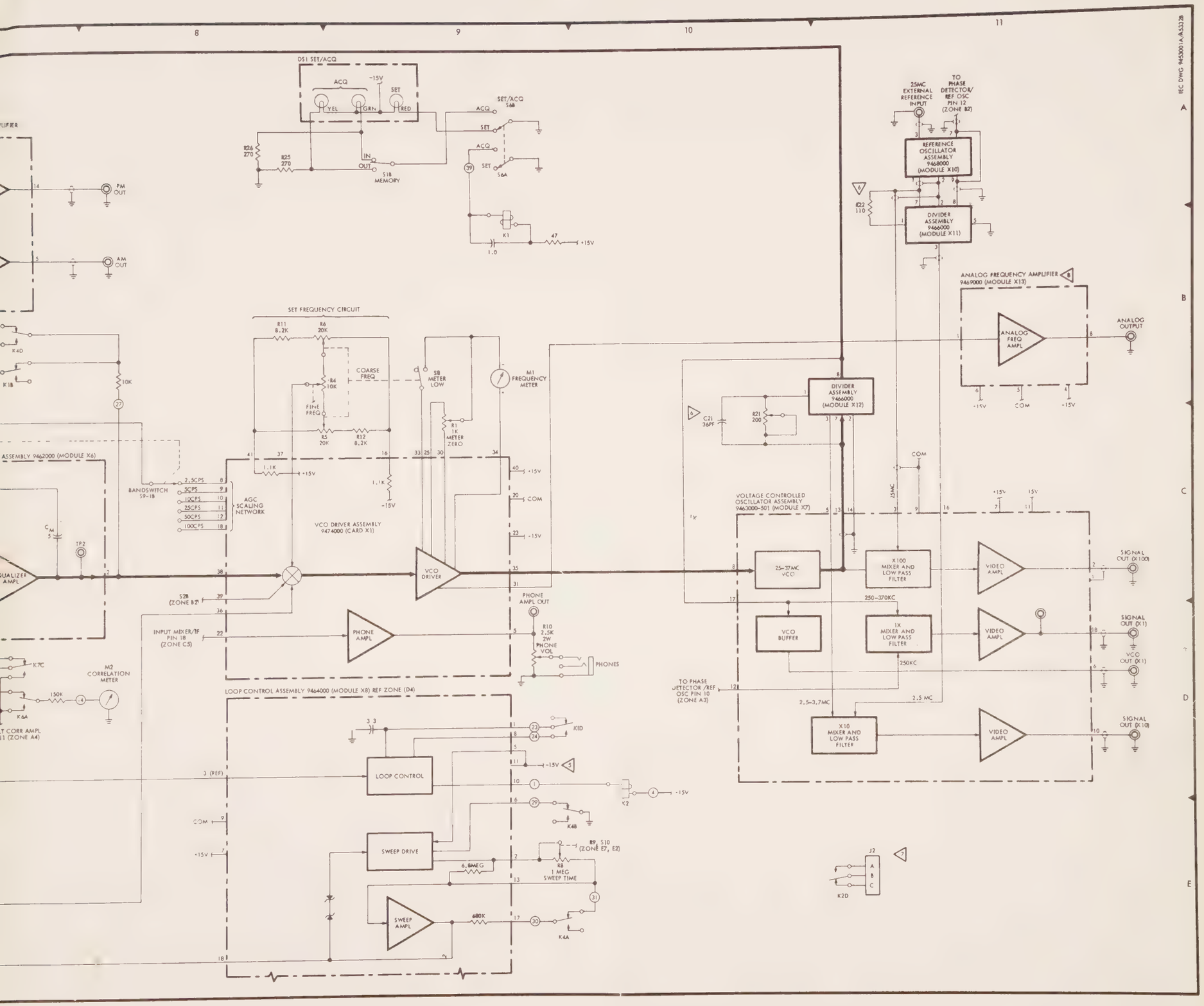


Figure 7-25. Phase Lock Tracking Filter Model PL 307, Overall System Diagram

Appendix

Interstate Tracking Filter Power Supplies

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1. GENERAL.

The Interstate solid-state tracking filter requires direct-current operating potentials of +15 and -15 volts. As shipped from the factory, any one of four different power supply modules is included in the tracking filter assembly to fill these power requirements. Early tracking filters employed two Universal Electronics Model SMFT-15-1 supply modules. This configuration was replaced by a dual-output module manufactured by P. R. Mallory and Co. Two versions of this supply module, reflecting slight circuit differences, are employed. Later tracking filters employ a Power Instruments Corp. Model PS1450 power supply module. With the exception of variations in mounting requirements, each supply configuration is physically and electrically interchangeable as far as tracking filter applications are concerned.

This appendix contains a general description, wiring connection and output adjustment information, a list of replaceable parts, and a schematic diagram for each of the power supply modules.

The individual lists of replaceable parts are composed only of those parts which are normally subject to electrical and mechanical failure. Hardware and other mechanical parts are not included. The first column of each list provides the reference symbols for each part in alpha-numeric order. These reference symbols are keyed to the schematic diagram. The second column lists the item name. The manufacturer's part number is indicated in the third column. The fourth column lists the numerical code number designating the manufacturer of the part. The total quantity of like parts is listed in the fifth column.

A compilation of vendor code numbers precedes each parts list. This table lists the names and addresses of manufactures of the items listed. Code numbers used are from the Department of Defense Cataloging Handbook H4-2, Federal Supply Code for Manufacturers, dated October 1959, and current supplements.

2. UNIVERSAL ELECTRONICS POWER SUPPLY MODEL SMFT-15-1.

a. GENERAL DESCRIPTION. - The Model SMFT-15-1 is a modular solid-state power supply, capable of operating within the specifications listed in table 1.

TABLE 1. TECHNICAL SPECIFICATIONS

Parameter	Description
Input:	105 - 125 volts, 50 - 500 cps, single phase.
Outputs:	15-volt dc at 1 ampere. 6.3-volt ac at 1 ampere.
Line and Load Regulation (d-c output only):	±0.1%.
Ripple:	1 mv rms maximum.
Temperature Coefficient:	0.03% per degree Centigrade.
Maximum Operating Temperature:	60^{O} Centigrade.

The applied a-c power is connected through transformer T1, where it is stepped down and coupled to three secondary windings. The a-c output at transformer secondary pins 3, 4, and 5 is rectified by diodes CR9 and CR10, filtered by capacitor C2, and applied to the applied to the collector of series regulator transistor Q2. This stage is controlled by driver transistor Q3, current amplifier Q4, and difference amplifier Q5 and Q6. Any change in the output voltage is seen as a change in base current at Q6, resulting in a like change in the output of base regulated transistor Q5. This change is amplified by Q4 and applied to driver transistor Q3. The output of Q3 directly controls the series regulator transistor. Transistor Q1 provides circuit overload protection. As the emitter voltage of this stage is lowered due to excessive output current demands, the collector voltage is also lowered. This results in a lowering of the base voltage of driver transistor Q3, which in turn cuts off series regulator Q2, driving the output towards zero.

The a-c output at transformer secondary pins 6, 7, and 8 is rectified by diodes CR1 and CR5, filtered by capacitor C1, and referenced to the output d-c voltage. This d-c voltage is used as a bias source for driver transistor Q3. A 6.3-volt a-c potential is made available to the tracking through transformer secondary pins 9 and 10 and module terminals 6 and 7.

b. CONNECTIONS AND ADJUSTMENTS. - All input and output connections to the Model SMFT-15-1 are made at terminals on the bottom of the unit. The terminals are marked with numbers corresponding to terminal numbers on the schematic diagram. The output voltage adjust control is located near the top, and is accessible for screwdriver adjustment through a hole in the cover.

Because two of the Model SMFT-15-1 supplies are used to provide plus and minus 15 volts with a common return line, the (+) output (terminal 4) of one unit and the (-) output (terminal 3) of the other are connected together and to chassis common. For 105 - 125-volt a-c operation, the two a-c inputs are connected in parallel. For 210 - 250-volt a-c applications, the two a-c inputs are connected in series.

c. REPLACEABLE PARTS. - Table 2 is a list of manufacturers for the Model SMFT-15-1 replaceable parts. An itemized listing of the replaceable parts for this unit is presented in table 3.

d. SCHEMATIC DIAGRAM. - Figure 1 is a schematic diagram for Universal Electronics Power Supply Model SMFT-15-1.

TABLE 2. LIST OF MANUFACTURERS

Code	Manufacturer
00656	Aerovox Corp., New Bedford, Massachusetts
01295	Texas Instruments Laboratory, Division of Culter-Hammer, Inc., Garden City, New York
07716	International Resistance Co., Burlington, Iowa
07910	Continental Device Corp., Hawthorne, California
12060	Diodes, Inc., Canoga Park, California
12711	Western Semiconductors, Inc., Santa Ana, California
14655	Cornell-Dubilier Electric Corp., Newark, New Jersey
14982	Secoa Electronics Corp., Westbury, New York
44655	Ohmite Mfg., Skokie, Illinois
56289	Sprague Electric Co., North Adams, Massachusetts
72699	General Instrument Corp., Newark, New Jersey
79727	Wirt Co., Philadelphia, Pennsylvania
97328	Universal Electronics Co., Santa Monica, California
99942	Hoffman Semiconductor Division of Hoffman Electronics Corp., Evanston, Illinois

3. MALLORY POWER SUPPLY 28-03000.

a. GENERAL DESCRIPTION. - Mallory Power Supply 28-03000 is a completely solid-state device, featuring a dual plus and minus 15-volt d-c output symmetrical about a common line. Each output can be adjusted independently ±5 percent, or both outputs can be simultaneously adjusted ±5 percent about the common line. Both outputs are overload protected and interacting so that an overload on one output will cause both outputs to respond identically. Technical specifications for the Mallory Power Supply are listed in table 4.

TABLE 3. REPLACEABLE PARTS FOR UNIVERSAL ELECTRONICS POWER SUPPLY MODEL SMFT-15-1

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
	POWER SUPPLY	SMFT15-1	97328	1	
C1	CAP.FXD ELECT	MLV25-50	72699	1	
C2	CAP.FXD ELECT	BR1000-25	14655	1	
C3	CAP.FXD PAPER	P829ZN7	00656	1	
C4	CAP.FXD ELECT	TE1307	56289	1	
C5	CAP.FXD PAPER	118P33392S4	56289	1	
CR1-CR3	SEMICONDUCTOR	DI1001	12060	8	
CR4	SEMICONDUCTOR	CD22	07910	1	
CR5-CR7	SEMICONDUCTOR	DI1001	12060	REF	
CR8	SEMICONDUCTOR	CD32897	07910	1	
CR9,CR10	SEMICONDUCTOR	DI52	12060	2	
CR11,CR12	SEMICONDUCTOR	DI1001	12060	REF	
CR13	SEMICONDUCTOR	1N756	99942	1	
CR14	SEMICONDUCTOR	WZ724	12711	1	
Q1	TRANSISTOR	TI484	01295	1	
Q2	TRANSISTOR	SEC1109A	14982	1	
Q3	TRANSISTOR	T1487	01295	1	
Q4-Q6	TRANSISTOR	TI495	01295	3	
R1	RES,FXD WIRE	4411	44655	1	
R2	RES,FXD COMP	RC20GF751J	44655	1	
R3	RES,FXD COMP	RC20GF470J	44655	2	
R5	RES,FXD WIRE	4419	44655	1	
R6	RES,FXD FILM	MEB/T0-1001F	07716	1	
R7,R8	RES,FXD COMP	RC20GF512J	44655	2	
R9	RES,FXD FILM	MEB/T0-1201F	07716	2	
R10	RES,FXD COMP	RC20GF470J	44655	REF	
R11	RES,VAR COMP	WC816D1K	79727	1	
R12	RES,FXD COMP	RC20GF102J	44655	1	
R13	RES,FXD FILM	MEB/T0-1201F	07716	REF	
R14	RES,FXD FILM	MEB/T0-1802F	07716	1	
T1	TRANS,PWR	315-1S	97328	1	

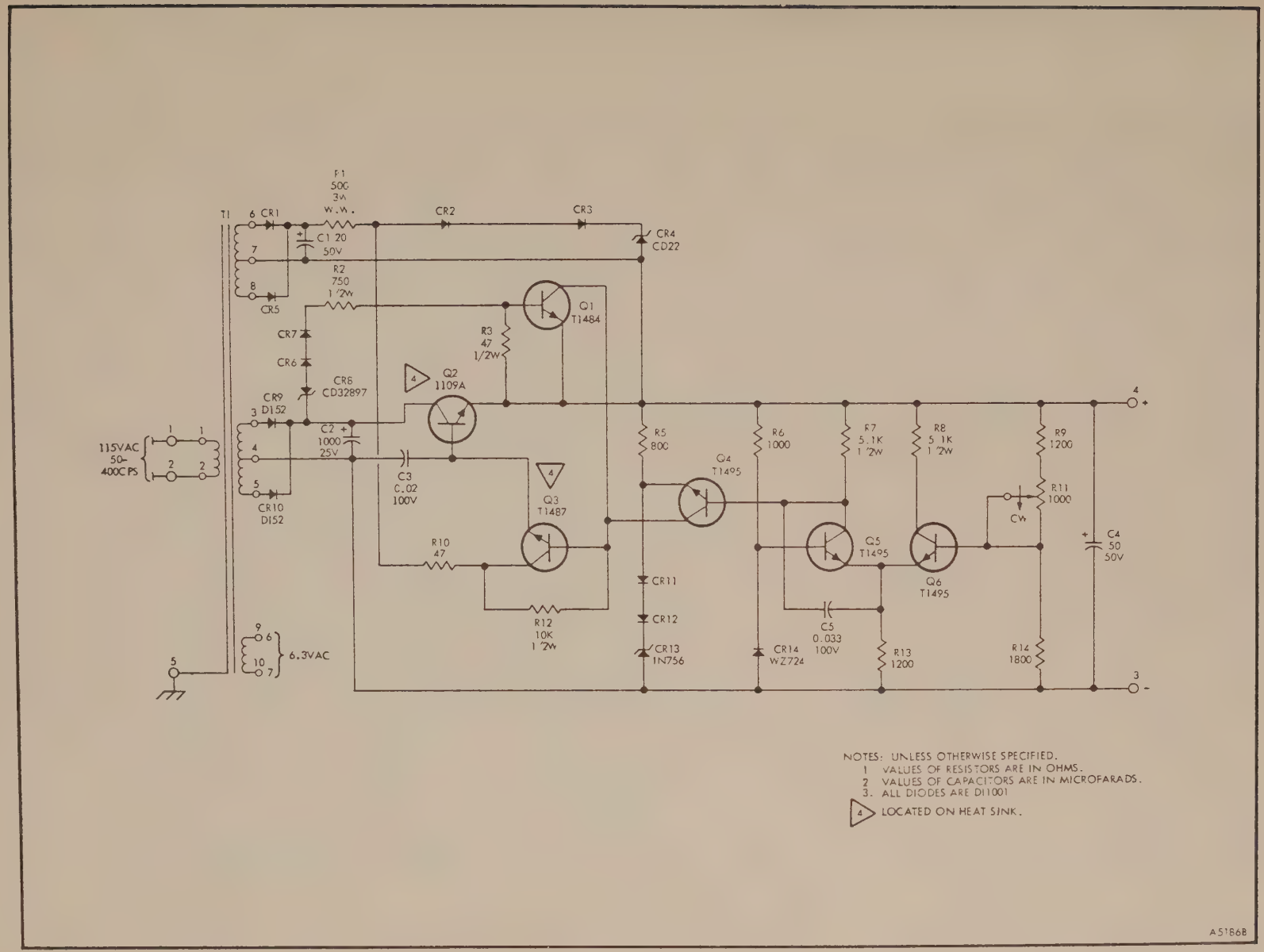


Figure 1. Universal Electronics Power Supply Model SMFT-15-1, Schematic Diagram

TABLE 4. TECHNICAL SPECIFICATIONS

Parameter	Description
Input:	105 - 125 volts, 50 - 400 cps, single phase or 210 - 250 volts, 50 - 400 cps, single phase.
Outputs:	+15 volts at 1 ampere. -15 volts at 1 ampere. 6.3 volts at 2 amperes center tapped.
Line and Load Regulations:	±10 mv total.
Ripple:	1 mv rms, maximum.
Temperature Coefficient:	1 mv per degree Centigrade.

There are two different circuit configurations for this power supply. Both configurations perform identical functions, and will meet the same general specifications; therefore, the following description is applicable to both circuit configurations. A schematic diagram for both circuit configurations is shown. The table of replaceable parts applies in general to both configurations; however, a few minor differences are indicated in subparagraph c. The input a-c voltage is applied to power transformer T1, stepped down, and applied to bridge rectifiers CR1 thru CR4, and the 6.3-volt a-c output. The output of the rectifiers is applied to filter capacitors C2, C3, and C4, and series regulator transistors Q1 and Q4. The negative series regulator is controlled by negative regulation balanced amplifier circuit Q12 and Q13, temperature compensated Zener diode CR25, and current amplifiers Q3 and Q8. The positive series regulator is controlled by positive regulation balanced amplifier circuit Q6 and Q7, and current amplifiers Q2 and Q5. The positive regulator circuits use the negative output as a reference voltage rather than a compensated Zener diode. The positive overload circuit consists of base driver limited series power transistor Q4 and clamp transistor Q15. The negative overload circuit consists of base driver limited series power transistor Q11, and clamp transistor Q10. As the voltage drop across either series power transistor exceeds a preset limit, the series transistor is shut off by the clamp transistor. When either series transistor is shut off, both outputs are simultaneously reduced to zero. R34 is the positive output voltage adjust, and R35 adjusts the negative output voltage.

NOTE

Because the positive regulator circuits use the negative supply as a reference, any adjustment of the negative voltage adjust will affect the positive output as well as the negative output.

b. CONNECTIONS AND ADJUSTMENTS. - All input and output connections to the Mallory Model 28-03000 are made at the bottom of the unit. All input terminals are marked with numbers corresponding to the schematic diagram. The schematic diagrams show the input connections for 105 - 120-volt operation; connections for 210 - 250-volt operation are indicated in an accompanying note. The output voltage adjust potentiometers are located near the top of the unit, and are accessible through a small hole next to the heat sink. The overload controls are factory preset, and should not require adjustment.

c. REPLACEABLE PARTS. - Table 5 is a list of manufacturers for the Mallory 28-03000 replaceable parts. An itemized listing of replaceable parts is presented in table 6. This listing corresponds to the Mallory circuit configuration illustrated by the schematic diagram of figure 2.

Replaceable parts for the Mallory circuit configuration illustrated in figure 3 is identical to the listing in table 6, with the following exceptions:

(1) The following additional parts are included: CR9, CR10, CR12, CR13, CR18, CR19. All are DI-505, vendor code 12060.

(2) Diodes CR8 and CR11 are DI-505, vendor code 12060.

(3) Transistors Q6/Q7 and Q12/Q13 are matched pairs, ME-217, vendor code 73445.

(4) The following differences in resistor values should be noted: R2 and R10 are 470 ohm, 1/2 watt; R21 is 1,000 ohms ±1 percent; R23 is 2,810 ohms ±1 percent, R24 is 4,700 ohms ±5 percent; R30 and R32 are 3,010 ohms ±1 percent.

d. SCHEMATIC DIAGRAMS. - Figures 2 and 3 are schematic diagrams for the two Mallory 28-03000 circuit configurations employed in the Interstate tracking filter.

4. POWER INSTRUMENTS POWER SUPPLY MODEL PS1450.

a. GENERAL DESCRIPTION. - The Model PS1450 is a completely solid-state dual plus and minus 15-volt d-c power supply. Each output is adjustable ±5 percent about a common line. Each output is overload protected, and both outputs will reduce to zero in event either output is overloaded. Each output is capable of supplying three times full load for 100 milliseconds before the overload circuits reduce the output to zero. In addition to operating with a nominal a-c input, the Model PS1450 has the capability of accepting a plus and minus 17 - 24-volt unregulated d-c input (with the same common return) as a source voltage. This power supply will meet, or exceed, the technical specifications listed in table 4.

TABLE 5. LIST OF MANUFACTURERS

Code	Manufacturer
01295	Texas Instruments Laboratory, Division of Culter-Hammer, Inc., Garden City, New York
03508	General Electric Co., Semi-Conductor Products Department of Electronic Components Division of Electronic, Atomic and Defense Sustems Group, Syracuse, New York
04713	Motorola, Inc., Semiconductor Products Division, Phoenix, Arizona
12040	National Semiconductor Corp., Danbury, Connecticut
12060	Diodes, Inc., Canoga Park, California
44655	Ohmite Mfg. Co., Skokie, Illinois
71590	Centralab Division of Globe Union, Inc., Milwaukee, Wisconsin
73293	Hughes Products Division of Hughes Aircraft Co., Los Angeles, California
73445	AMPEREX Electronic Co. Division of North American Philips Co., Inc., Hicksvile, New York
80294	Bourns Laboratories, Inc., Riverside, California
82398	Wama Co., Baltmore, Maryland
90201	P. R. Mallory and Co., Inc., Detroit, Michigan

The a-c input voltage is applied to power transformer T1, stepped down, and applied to a full-wave bridge rectifier consisting of CR20 through CR23. The output of the rectifiers, or (in the case of d-c operation) the input dc, is applied to filter capacitors C20 and C22, and to series regulator transistors Q6 and Q7. The output of each series regulator is controlled by the associated regulator circuits for each of the interdependent supplies. The positive voltage regulator circuits consist of difference amplifier circuit Q1 and Q2, and current amplifiers Q3 and Q4. The output of current amplifier Q4 controls the output of positive series regulator Q6. Transistor Q5 is the overload control transistor for the positive regulator. The negative voltage regulator circuits consist of difference amplifier circuit Q15 and Q16, and current amplifiers Q18 and Q19. Transistor Q17 is an isolating emitter follower between the difference amplifier circuit, and the first current amplifier (Q19). The output of the second current amplifier (Q18) controls negative series regulator Q7. Transistor Q20 is the overload control transistor for the negative regulator. The regulator circuits are interdependent; therefore, any level change at the output of one side will result in a level change at the output of the other side.

b. CONNECTIONS AND ADJUSTMENTS. - All input and output connections to the Model PS1450 are made on the bottom of the module. The input and output terminals are marked with J-numbers corresponding to the numbers on the schematic diagram. The power supply mounting bracket is also marked with the respective J-number. The Model PS1450 is normally connected for 105 - 125-volt operation. If 210 - 250-volt operation is desired, remove the jumper wires between terminals J1 and J2, and terminals J3 and J4 and install a jumper wire between J2 and J3. Primary power can then be applied across terminals J1 and J4.

TABLE 6. REPLACEABLE PARTS FOR MALLORY POWER SUPPLY 27-03000

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
	POWER SUPPLY	28-03000	90201	1	
C1	CAP.FXD ELECT	TAP306U040P0B	90201	1	
C2,C3	CAP.FXD ELECT	TS18630	90201	2	
C4	CAP.FXD ELECT	TAP306U090P0B	90201	1	
C5,C6	CAP.FXD CERAMIC	DDA104	71590	2	
C7	CAP.FXD ELECT	TAM566M006P5C	90201	2	
C8	CAP.FXD ELECT	TAP256U050P0B	90201	1	
C9	CAP.FXD ELECT	TAM566M006P56	90201	REF	
C10,C11	CAP.FXD ELECT	TAP106U025P5C	90201	1	
C12,C13	CAP.FXD ELECT	TS18178	90201	1	
CR1-CR5	SEMICONDUCTOR	1N1613	82398	5	
CR6,CR7	SEMICONDUCTOR	DI505	12060	11	
CR8	SEMICONDUCTOR	ZA6.8A	90201	2	
CR11	SEMICONDUCTOR	ZA6.8A	90201	REF	
CR14-CR17	SEMICONDUCTOR	DI505	12060	REF	
CR20-CR24	SEMICONDUCTOR	DI505	12060	REF	
CR25	SEMICONDUCTOR	1N2621	04713	1	
Q1	TRANSISTOR	2N2156	04713	4	
Q2,Q3	TRANSISTOR	2N696	03508	4	
Q4	TRANSISTOR	2N2156	04713	REF	
Q5	TRANSISTOR	2N1623	73293	2	
Q6,Q7	TRANSISTOR	2N2712	03508	4	
Q8	TRANSISTOR	NS664	12040	1	
Q9,Q10	TRANSISTOR	2N696	03508	REF	
Q11	TRANSISTOR	2N2156	04713	REF	
Q12,Q13	TRANSISTOR	2N2712	03508	REF	
Q14	TRANSISTOR	2N2156	04713	REF	
Q15	TRANSISTOR	2N1623	73293	REF	
R1	RES,FXD COMP	RC07GF330J	44655	1	
R2	RES,FXD COMP	RC07GF221J	44655	2	
R3,R4	RES,FXD COMP	RC07GF102J	44655	7	
R5	RES,FXD COMP	RC07GF152J	44655	1	
R6	RES,FXD COMP	RC07GF822J	44655	1	
R7	RES,FXD COMP	RC07GF102J	44655	REF	
R8	RES,FXD COMP	RC07GF222J	44655	2	
R9	RES,FXD COMP	RC32GF391J	44655	1	
R10	RES,FXD COMP	RC07GF221J	44655	REF	
R11	RES,FXD WIRE	4404	44655	1	
R12	RES,FXD COMP	RC07GF102J	44655	REF	
R13	RES,FXD COMP	RC07GF151J	44655	1	
R14	RES,ADJ WIRE	260P1-103	80294	1	
R15	RES,FXD COMP	RC07GF332J	44655	2	
R16	RES,FXD COMP	RC07GF102J	44655	REF	
R17	RES,FXD COMP	RC07GF332J	44655	REF	
R18,R19	RES,FXD COMP	RC07GF102J	44655	REF	
R20	RES,FXD COMP	RC07GF150J	44655	2	

Table 6. Replaceable Parts for Mallory Power Supply 27-03000 (Continued)

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R21	RES,FXD COMP	RC07GF472J	44655	2	
R22	RES,FXD COMP	RC07GF680J	44655	1	
R23	RES,FXD COMP	RC07GF272J	44655	1	
R24	RES,FXD COMP	RC07GF472J	44655	REF	
R25	RES,FXD FILM	CG1/4-5600F	01295	1	
R26	RES,FXD COMP	RC07GF182J	44655	1	
R27	RES,FXD COMP	RC07GF150J	44655	REF	
R28	RES,FXD COMP	RC07GF102J	44655	REF	
R29	RES,FXD COMP	RC07GF222J	44655	REF	
R30	RES,FXD FILM	CG1/4-1821F	01295	2	
R31	RES,ADJ WIRE	260P1-201	80294	3	
R32	RES,FXD FILM	CG1/4-1821F	01295	REF	
R33	RES,FXD COMP	RC32GF271J	44655	REF	
R34	RES,ADJ WIRE	260P1-201	80294	REF	
R35	RES,FXD FILM	CG1/4-5110F	01295	1	
R36	RES,ADJ WIRE	260P1-201	80294	REF	
R37	RES,FXD FILM	CG1/4-8450F	01295	1	
T1	TRANS,PWR	28-03004	90201	1	

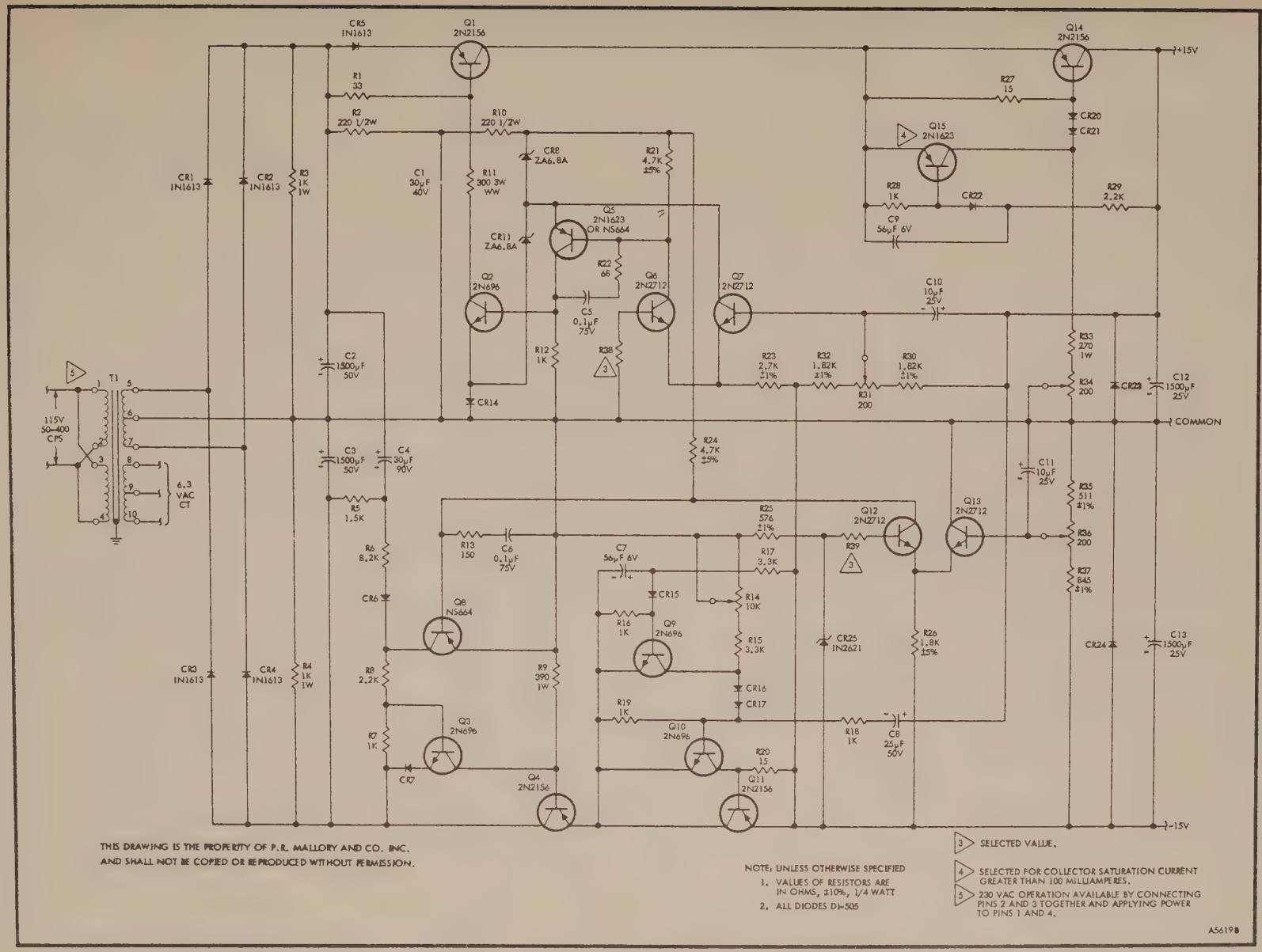


Figure 2. Mallory Power Supply 28-03000, Schematic Diagram

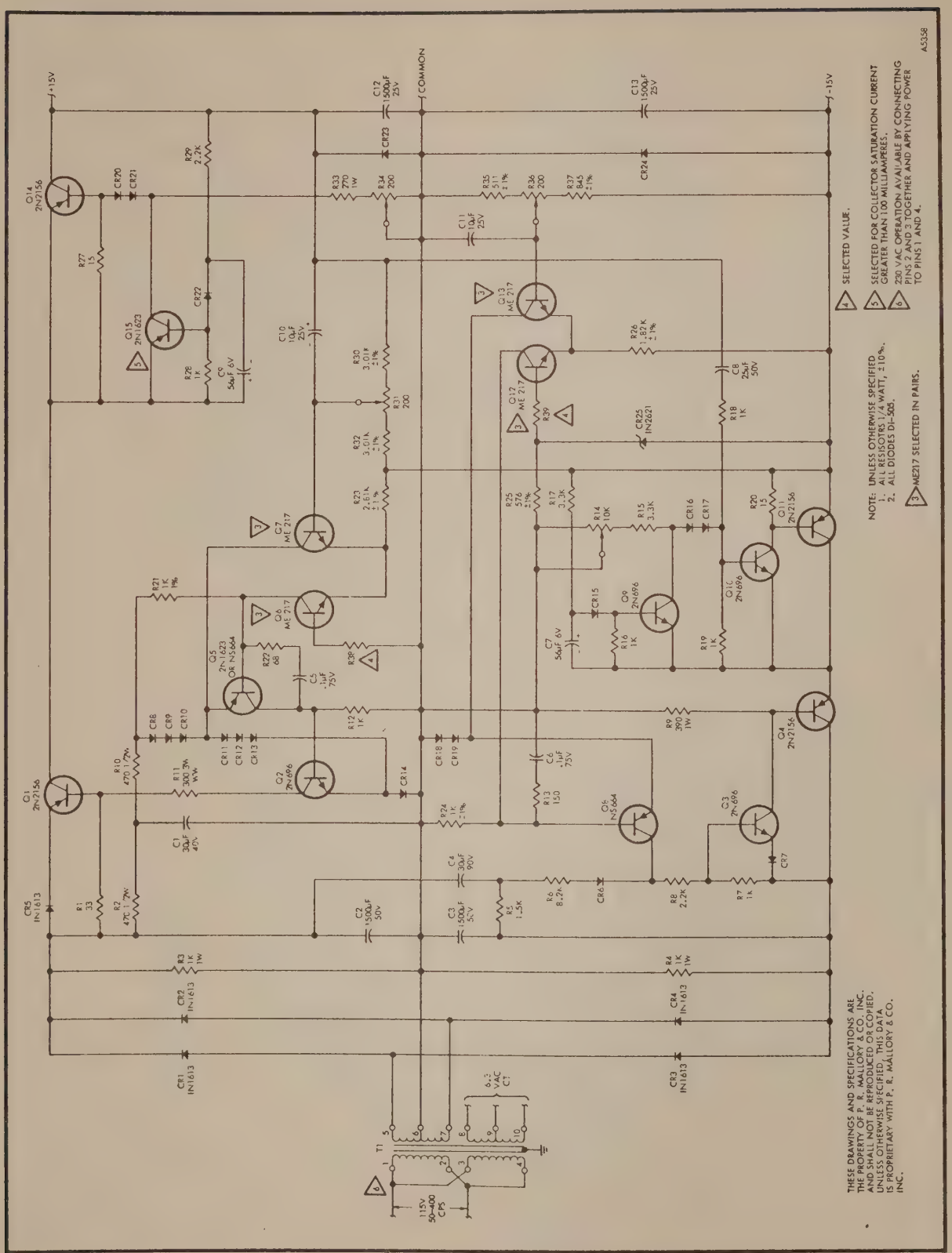


Figure 3. Mallory Power Supply 28-03000, Schematic Diagram

Output voltage adjust controls R3 (+) and R31 (-) are located near the top of the module, and are accessible for adjustment through a small hole located to the side of the heat sink. The overload adjust controls are factory preset, and should not require adjustment.

c. REPLACEABLE PARTS. - Table 7 is a list of manufacturers for the Model PS1450 replaceable parts. An itemized listing of the replaceable parts for this unit is presented in table 8.

d. SCHEMATIC DIAGRAM. -Figure 4 is a schematic diagram for Power Instruments Power Supply Model PS1450.

TABLE 7. LIST OF MANUFACTURERS

Code	Manufacturer
01281	Pacific Semiconductors, Inc., Culver City, California
01295	Texas Instruments Laboratory, Division of Culter-Hammer, Inc., Garden City, New York
04713	Motorola, Inc., Semiconductor Products Division, Phoenix, Arizona
05277	Westinghouse Electric Corp., Semiconductor Department, Youngwood, Pennsylvania
12069	Power Instruments Corp., El Segundo, California
44655	Ohmite Mfg. Co., Skokie, Illinois
56289	Sprague Electric Co., North Adams, Massachusetts
73293	Hughes Products Division of Hughes Aircraft Co., Los Angeles, California
80294	Bourns Laboratories, Inc., Riverside, California
81483	International Rectifier Corp., El Segundo, California
99515	Electron Products, Inc., Pasadena, California

TABLE 8. REPLACEABLE PARTS FOR POWER INSTRUMENTS

POWER SUPPLY MODEL PS 1450

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
	POWER SUPPLY	PS1450	12069	1	
C1	CAP.FXD ELECT	SCM226GP020D2	01295	2	
C2	CAP.FXD PLASTIC	W1-472	99515	1	
C4	CAP.FXD ELECT	SCM227HP010D2	01295	2	
C14	CAP.FXD ELECT	SCM226GP020D2	01295	REF	
C15	CAP.FXD PLASTIC	W1-202	99515	1	
C16	CAP.FXD PLASTIC	M1-104	99515	1	
C17	CAP.FXD ELECT	SCM105FP035D2	01295	1	
C18	CAP.FXD ELECT	SCM227HP010D2	01295	REF	
C20	CAP.FXD ELECT	36D2066	56289	2	
C21	CAP.FXD ELECT	36D2065	56289	2	
C22	CAP.FXD ELECT	36D2066	56289	REF	
C23	CAP.FXD ELECT	36D2065	56289	REF	
CR1	SEMICONDUCTOR	1N645	01295	5	
CR2	SEMICONDUCTOR	69-5252	81483	2	
CR3	SEMICONDUCTOR	1N645	01295	REF	
CR4	SEMICONDUCTOR	1N1199A	05277	5	
CR13	SEMICONDUCTOR	1N645	01295	REF	
CR14	SEMICONDUCTOR	1N936	04713	1	
CR15,CR16	SEMICONDUCTOR	1N645	01295	REF	
CR17	SEMICONDUCTOR	69-5252	81483	REF	
CR20-CR23	SEMICONDUCTOR	1N1199A	05277	REF	
Q1-Q5	TRANSISTOR	PT1878	01281	10	
Q6,Q7	TRANSISTOR	2N2081A	04713	2	
Q15-Q18	TRANSISTOR	PT1878	01281	REF	
Q19	TRANSISTOR	2N1131	73293	1	
Q20	TRANSISTOR	PT1878	01281	REF	
R1,R2	RES,FXD FILM	RN60B1821F	44655	2	
R3	RES,ADJ WIRE	3067P1-201	80294	3	
R4	RES,FXD COMP	RC20GF682J	44655	1	
R5	RES,FXD COMP	GF302J	44655	3	
R6	RES,FXD COMP	RC20GF432J	44655	2	
R7,R8	RES,FXD COMP	RC20GF470J	44655	2	
R9	RES,FXD COMP	RC20GF102J	44655	1	
R10	RES,FXD WIRE	3067	44655	1	
R11	RES,FXD COMP	RC20GF100J	44655	1	
R12	RES,FXD COMP	RC20GF103J	44655	2	
R13	RES,FXD COMP	RC20GF471J	44655	1	
R14	RES,ADJ WIRE	3067P1-201	80294	REF	
R15	RES,FXD COMP	RC32GF751J	44655	1	
R16	RES,FXD COMP	RC32GF102J	44655	1	
R17	RES,FXD COMP	RC20GF101J	44655	1	
R18	RES,FXD COMP	RC20GF122J	44655	1	
R29	RES,FXD FILM	RN60B5110F	44655	1	
R30	RES,FXD FILM	RN60B8250F	44655	1	
R31	RES,ADJ WIRE	3067P1-201	80294	REF	

Table 8. Replaceable Parts for Power Instruments Power Supply Model PS 1450 (Continued)

1. REFERENCE SYMBOL 1 2 3 4 5	2. ITEM NAME 1 2 3 4 5	3. MANUFACTURER'S PART NO. FEDERAL STOCK NO.	4. MFR CODE	5. QTY PER UNIT	6. RECM SPARE
R32,R33	RES,FXD COMP	RC20GF153J	44655	2	
R34	RES,FXD COMP	RC20GF432J	44655	REF	
R35	RES,FXD COMP	RC20GF821J	44655	1	
R36	RES,FXD COMP	RC32GF392J	44655	1	
R37	RES,FXD COMP	RC20GF302J	44655	REF	
R38	RES,FXD COMP	RC20GF203J	44655	2	
R40	RES,FXD COMP	RC20GF203J	44655	REF	
R41	RES,FXD COMP	RC20GF331J	44655	1	
R42	RES,FXD COMP	RC20GF242J	44655	1	
R44	RES,ADJ WIRE	3067P1-202	80294	1	
R46	RES,FXD COMP	RC20GF822J	44655	1	
R47	RES,FXD COMP	RC20GF103J	44655	REF	
R48	RES,FXD COMP	RC32GF102J	44655	REF	
T1	TRANS,PWR SDN	AT342A	12069	1	

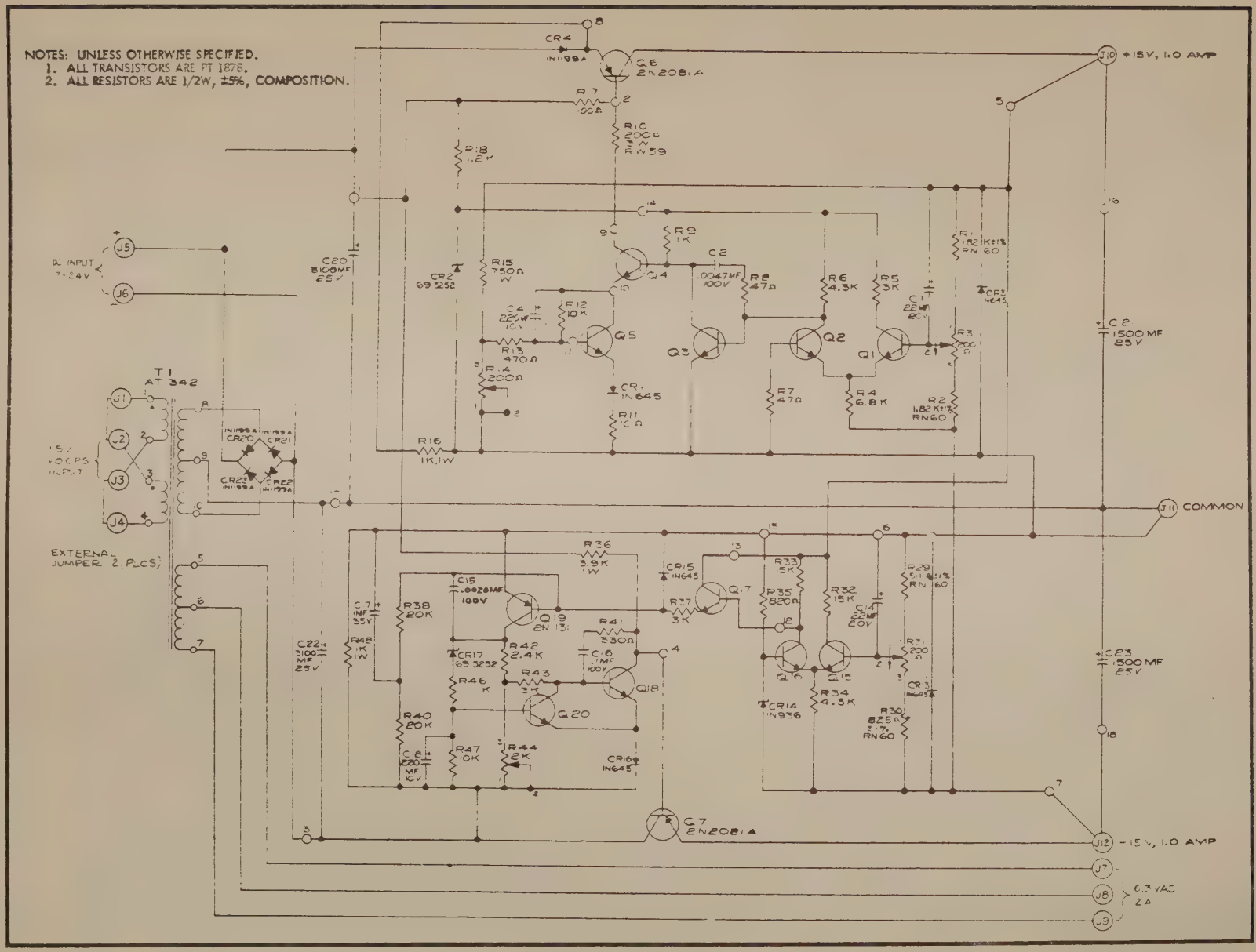


Figure 4. Power Instruments Power Supply Model PS1450, Schematic Diagram

WARRANTY

Interstate Electronics Corporation warrants each instrument manufactured by them to be free from defects in material and workmanship. Liability under this warranty is limited to servicing or adjustment of any instrument returned to the factory for that purpose and to replacement of any defective parts thereof. Electron tubes, fuses, and batteries are specifically excluded from any liability. This warranty is effective for 120 days after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, normal service charges will prevail. In this case, an estimate will be submitted before the work is started.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If the instrument is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number, serial number, and purchase order number when referring to this instrument for any reason.

SHIPPING

If the unit fails to operate or any fault develops, the following steps should be taken:

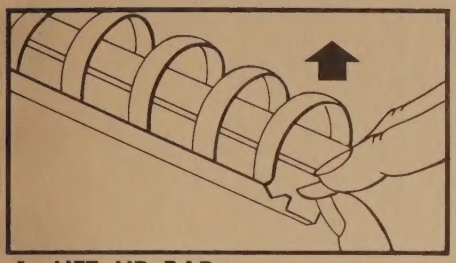
1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to Interstate Electronics Corporation or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

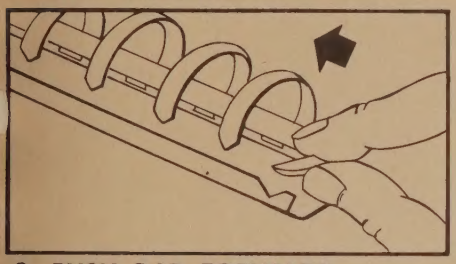
3. All shipments of equipment should be made as advised by Interstate Electronics Corporation. The equipment should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

Interstate
ELECTRONICS CORPORATION
707 EAST VERMONT AVENUE, ANAHEIM, CALIFORNIA
A SUBSIDIARY OF INTERSTATE ENGINEERING CORPORATION
MARKETING DEPARTMENT
Telephone: 714-772-2222
TWX: 714-776-0280

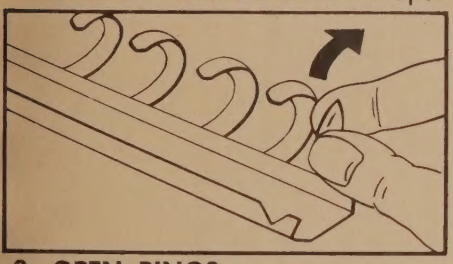
How to Operate This BINDEMATIC BINDER



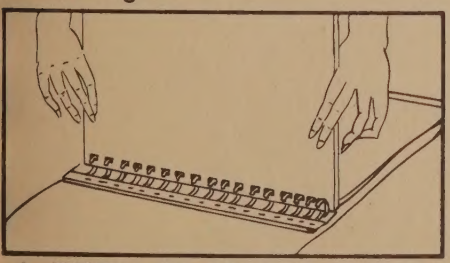
1. LIFT UP BAR
With thumb and forefinger, lift up plastic bar over tip of aluminum channel.



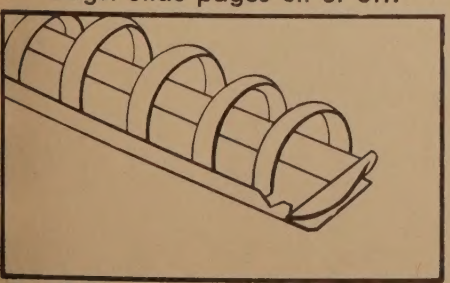
2. PUSH BAR FORWARD
Slide bar forward until it stops.



3. OPEN RINGS
Turn bar to right, opening plastic rings.



4. INSERT OR REMOVE SHEETS
Line up holes in sheets with rings. Slide pages on or off.



5. LOCK BINDER
Close rings by pushing bar down. Pull bar back to original position.

MP MASTER
MA28304